INSTRUMENT SERVICES

INSTRUCTION MANUAL

MICROWAVE SWEEP OSCILLATOR

BASIC UNIT

MODEL 221

MP MASTER

MA31869

MICRO-POWER INC. 25-14 BROADWAY, LONG ISLAND CITY, NEW YORK 11106/(212)726-4060

INSTRUCTION MANUAL

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BASIC UNIT

MODEL 221

81K

Serial Number....._____

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NOTE: SEE REAR OF MANUAL FOR LATEST MANUAL CHANGES.

TABLE OF CONTENTS

Section	Page
1- 0. GENERAL INFORMATION	1-1
1- 1. Introduction	1-1
1- 2. Warranty	1-1
1- 3. Rack Mounting	1-1
1- 4. Shipping Damage	1-1
1- 5. Repacking for Shipping	1-1
2- 0. SPECIFICATIONS	2-1
3- 0. OPERATION	3-1
3- 1. Introduction	3-1
3- 2. Power Control	3-1
3- 3. Sweep Mode Selector	3-1
3- 4. External Sweep Mode	3-1
3- 5. F1-F2 Mode	3-1
3- 6. M1-M2 Marker Sweep Mode (Expanded Sweep)	3-2
3- 7. Symmetrical Sweep	3-2
3- 8. Symmetrical Center Frequency Selector	3-2
3- 9. CW Mode Selector	3-2
3-10. Sweep Time Selector	3-2
3-11. Manual Sweep	3-3
3-12. Sweep Triggering Selector	3-3
3-13. Amplitude Modulation Selector	3-3
3-14. RF Leveler	3-3
3-15. External Crystal Leveling	3-3
3-16. Power Meter Leveling	3-3
3-17. Sweep Output Amplitude	3-4
3-18. RF During Retrace On/Off	3-4
3-19. Internal Marker On/Off	3-4
3-20. Helix (HV) Supply Bandwidth	3-4
3-21. Remote Frequency Programming	3-4
3-22. INPUTS	3-5
3-23. External AM Input	3-5
3-24. Sweep Input	3-5
3-25. Trigger Input	3-5
3-26. AM Pulse Input	3-5
3-27. FM Input	3-5
3-28. External Detector Input	3-6
3-29. External Sweep Mode - Remote Frequency Control	3-6
3-30. Remote Level Control	3-6
3-31. OUTPUTS	3-6
3-32. RF Output	3-6
3-33. Sweep Output	3-6
3-34. Blanking Output	3-6
3-35. Internal Marker Output	3-6
3-36. Recorder Pen Lift	3-6
3-37. Proportional Sweep Output	3-6
4- 0. PRINCIPLES OF OPERATION	4-1
4- 1. General Block Diagram	4-1
4- 2. Sweep Generator	4-1
4- 3. Sweep Amplifier, F1-F2 or M1-M2	4-2
4- 4. Sweep Amplifier, Symmetrical M1 or Symmetrical Remote	4-2
4- 5. Sweep Amplifier, External Mode	4-3
4- 6. Sweep Amplifier, CW Mode	4-3
4- 7. Marker Generator	4-3
4- 8. Leveling Amplifier	4-3
4- 9. Grid Supply	4-4
4-10. Helix and Anode Supply	4-4
4-11. Collector, Filament and Auxiliary Supplies	4-5
4-12. Protective Circuits	4-5
4-13. Helix Overcurrent	4-5
4-14. Anode Overvoltage	4-5
4-15. Filament Overvoltage	4-5
4-16. Helix Undervoltage	4-5
4-17. High Voltage Interlock	4-5
5- 0. MAINTENANCE	5-1
5- 1. Performance Check	5-1
5- 2. Power Output Check	5-1
5- 3. Frequency Calibration Check	5-1
5- 4. Symmetrical Sweep Width Frequency Calibration and Check	5-1
5- 5. Residual FM Check	5-1
5- 6. Internal and External Trigger Check	5-2
5- 7. Leveling Check	5-2
5- 8. Internal Leveling Check	5-2
5- 9. External Leveling Check	5-2
5-10. Power Meter Leveling Check	5-3
5-11. Internal Square Wave Modulation	5-3
5-12. External AM Check	5-3
5-13. Calibration - Basic Unit	5-3
5-14. Test Equipment	5-3
5-15. Preparation of Equipment	5-3
5-16. Control Setting	5-4
5-17. Calibration Procedures	5-4
5-18. Calibration of Oscillator Unit	5-6

TABLE OF CONTENTS (CONT'D)

Section	Page
5-19. Periodic Maintenance	5- 7
5-20. Cleaning Air Filter	5- 7
5-21. Oiling the Fan Motor	5- 7
5-22. Removable Assemblies	5- 8
5-23. Plug-In Oscillator Unit	5- 8
5-24. Waveform Generator	5- 8
5-25. Identification of Subassemblies and Components	5- 8
5-26. Trouble Shooting Procedure	5- 8
5-27. General	5- 8
5-28. BWO Malfunction	5- 8
5-29. Schematic Diagrams	5- 9
6- 0. REPLACEABLE PARTS	6- 1
6- 1. Introduction	6- 1
6- 2. Reference Designations and Abbreviations	6- 1
6- 3. Ordering Information	6- 1

LIST OF TABLES

Table	Page
2- 1. Model 221 Plug-Ins and Accessories	2- 4
5- 0. Table of Test Equipment	5- 0
5- 1. Table of General Trouble Symptoms	5-10
5- 2. Trouble Shooting the Filament Supply	5-12
5- 3. Trouble Shooting the ±24VDC Supply	5-13
5- 4. Trouble Shooting the Helix Supply	5-14
5- 5. Trouble Shooting the Anode Supply	5-16
5- 6. Graphic Symbols	5-27
6- 1. Abbreviations and Reference Designations	6- 2
6- 2. Replaceable Parts	6- 3

LIST OF ILLUSTRATIONS

Figure	Page
1- 1. Rack Mounting	1- 2
2- 1. Dimensional Outline	2- 3
4- 1. General Block Diagram	4- 6
4- 2. Sweep Generator Block Diagram	4- 7
4- 3. Sweep Generator Waveforms	4- 8
4- 4. Sweep Amplifier Block Diagram	4- 9
4- 5. Sweep Amplifier Block Diagram	4- 9
4- 6. Sweep Amplifier Block Diagram	4-10
4- 7. Sweep Amplifier Block Diagram	4-10
4- 8. Marker Generator Block Diagram	4-11
4- 9. Leveling Amplifier Block Diagram	4-12
4-10. Grid Supply Block Diagram	4-13
4-11. Helix and Anode Supply Block Diagram	4-13
4-12. Collector, Filament and Auxiliary Supplies Block Diagram	4-14
5- 1. Frequency Measurement	5-18
5- 2. Frequency Discriminator	5-18
5- 3. External Leveling	5-18
5- 4. Power Level Check	5-18
5- 5. Squarewave Modulation	5-18
5- 6. ±24VDC and Filament Supply Calibration	5-19
5- 7. Waveform Generator Calibration	5-19
5- 8. Identification of Subassemblies and Components	5-20
5- 9. Sweep Generator PC Board Layout	5-21
5-10. Sweep Amplifier PC Board Layout	5-22
5-11. Power Supply PC Board Layout	5-23
5-12. Helix Anode Supply PC Board Layout	5-24
5-13. HV Rectifier PC Board Layout	5-25

TABLE OF CONTENTS (CONT'D)

Figure	Page
5-14. Grid Supply PC Board Layout	5-26
5-15. Proportional Output Amplifier and Negative Video Marker PC Board Layout	5-27
5-16. Sweep Generator Schematic	5-29
5-17. Sweep Amplifier Schematic	5-30
5-18. Marker/Square Wave Generator Schematic	5-31
5-19. ±24VDC, DC Filament, Filament/ Anode Trip Schematic	5-32
5-20. Helix/Anode Supplies Schematic	5-33
5-21. Grid Supply Schematic	5-34
5-22. Control Circuitry Schematic	5-35

SECTION 1-0
GENERAL DESCRIPTION

1-1. INTRODUCTION. The Model 221 Microwave Sweep Oscillator consists of a Basic Unit and a series of plug-in Oscillator Units. With an Oscillator Unit inserted into the Basic Unit, the equipment will meet the specifications listed in Section 2-0 of this manual and Section 2 of the manual associated with the inserted Oscillator Unit.

1-2. WARRANTY. The equipment warranty furnished by Micro-Power, Inc. is given on a separate form at the rear of this manual. The Microwave Tube is not manufactured by Micro-Power, Inc. Separate terms of warranty, specified by the tube manufacturers, apply and are described on a separate form at the rear of the Oscillator Unit instruction manual.

1-3. RACK MOUNTING. The equipment is furnished with two (2) rack mounting adaptors and handles. The adaptors are designed to be mounted on the sides of the two (2) front, vertical supports. To mount adaptors to equipment, remove adhesive trim strips located in grooves on both supports and use the screws provided to secure the adaptors to the supports (see Figure 1-1).

1-4. SHIPPING DAMAGE. Carefully inspect equipment immediately upon receipt. Do not discard any packing material until you are satisfied unit is working properly and no damage is evident. If shipping damages are found report all claims to carrier immediately.

1-5. REPACKING FOR SHIPPING. The following procedures should be followed in repacking:

a. Remove plug-in Oscillator Unit from Basic Unit. Plug-in Oscillator Unit and Basic Unit to be shipped in separate shipping containers.

b. Attach to unit to be shipped a tag indicating:

1. Service required
2. Description of equipment malfunction
3. Equipment model and serial numbers
4. Return address

c. Wrap instrument in heavy paper or plastic.

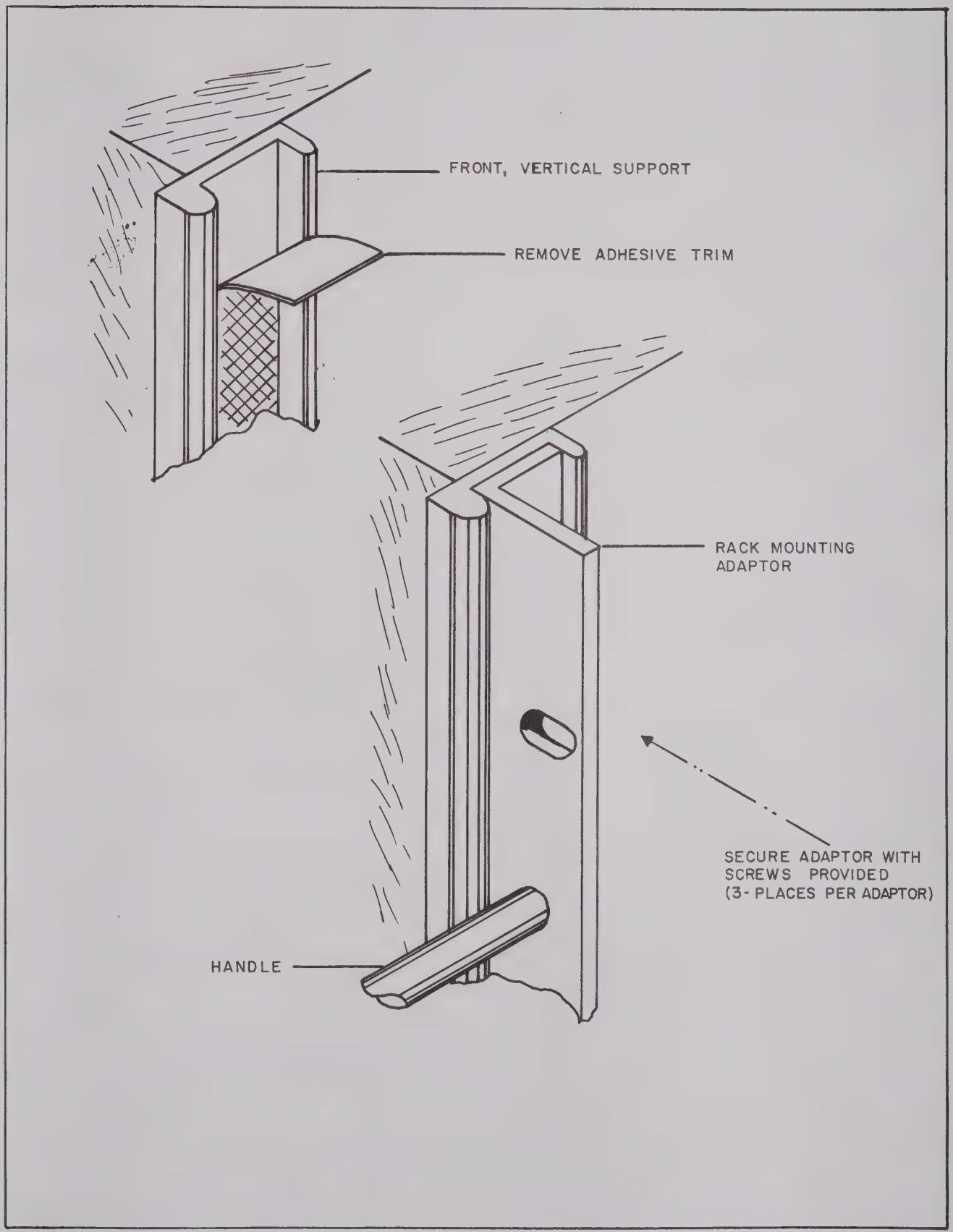
d. Place wrapped instrument in a strong shipping container providing enough shock absorbing material (3-4 inch layer) around all sides of the instrument to provide a firm cushion and prevent movement inside the container (use original shipping container whenever possible).

e. Thoroughly seal the shipping container.

f. Mark the shipping container "Fragile" to assure careful handling.

FIG. 1-1.

RACK MOUNTING



SECTION 2-0
SPECIFICATIONS

FREQUENCY:
FREQUENCY RANGE: The frequency range is determined by the plug-in oscillator used. Refer to Table 2-1.
FREQUENCY ACCURACY: BWO unit ±1%; VTM units ± 1.5%.
FREQUENCY LINEARITY: Same as Frequency Accuracy.
RF OUTPUT POWER: The power output is determined by the plug-in oscillator used. Refer to Table 2-1.

SWEEP REPRESENTATION:
END LIMIT: Between any two (2) frequencies in band.
MARKER END LIMIT: Between any two (2) frequencies in band.
SYMMETRICAL: Calibrated and adjustable from 0-100% of the total frequency band. Calibrated width accuracy ±10%. Center frequency can be centered on the position of the M1 indicator or on a frequency set by a remote potentiometer.
EXTERNAL: Direct coupled 20 volts for full sweep, positive voltage increases RF frequency. Response time: 200 microseconds for full sweep with increasing frequency and 2 milliseconds for full sweep with decreasing frequency. Provision for external resistance programming.
CW OPERATION: Four (4) independent single frequencies calibrated and continuously variable.

MARKER: Two (2) independent adjustable markers displayed either as dips in RF output or externally as positive video markers. Negative video markers available via rear panel jumper.
ACCURACY: BWO units ±1%, VTM units ±1.5%.
RESOLUTION: Less than 0.05% of sweep range.
AMPLITUDE: Continuously variable.
OUTPUT: Auxiliary video marker, amplitude 5 volts.

SWEEP RATE:
AUTOMATIC: Decade from 100 seconds/sweep to .01 seconds/sweep, vernier 10-1 continuously variable.

MANUAL: The RF output frequency can be manually swept between the limits set in the end limit or symmetrical sweep modes.

TRIGGERED SWEEP:
INTERNAL: Recurrent
LINE: Line frequency
EXTERNAL: 10 volts input with 1 microsecond minimum duration.
MANUAL: Front panel pushbutton.

SWEEP DWELL TIME: Delay in the start of sweep long enough to allow the RF power level to stabilize.

SWEEP OUTPUT: Direct coupled, adjustable from 0-15 volts peak.
SWEEP ON INDICATOR: An indicator is lighted during the forward direction of sweep, the indicator is off at all other times.

PROPORTIONAL OUTPUT: Direct coupled voltage proportional to instantaneous frequency; 0 volts at low end and 10 volts at high end.

BLANKING OUTPUT: 20 volts negative.

PEN LIFT: Relay contact closure during forward trace portion of sweep. Input to contacts should not exceed +24VDC or 240ma.

BASE LINE: Switch selects RF ON or OFF during retrace.

FREQUENCY STABILITY:
RESIDUAL FM: BWO units: 2 ppm peak see Paragraph 5-5 of the Model 221 Basic Unit Instruction Manual.
VTM units: 10 ppm typical.
LINE REGULATION: ±5 ppm maximum for a ±10% change in line voltage.

LEVELED RF OUTPUT: Internal feedback amplifier maintains output power variation to within 0.1 dB plus coupler and detector variation. When operated with internal directional detector, total power variation is as indicated on Page 1 of the Oscillator Unit Manual. Optional

use with external directional coupler and RF crystal detector or RF power meter.

MODULATION:
INTERNAL AM: Square wave modulation adjustable from 950-1050 Hz.
EXTERNAL AM: 20 volts positive signal increases RF output to maximum, rise and fall times are 1.0 microseconds unleveled and approximately 10 microseconds leveled.
For Grid leveled BWO units only and operating in the unleveled mode, a pulse signal applied through the AM pulse input will provide rise and fall times of 0.1 microseconds.
EXTERNAL FM: BWO units; direct coupled input provides frequency response in excess of 5MHz.

RESIDUAL AM: 40 dB below rated RF output.

SPURIOUS SIGNALS: Non-Harmonics 40 dB below rated RF output; harmonics 20 dB below rated RF output.

GENERAL:
DIMENSIONS: 8 3/4" high x 17 1/4" wide x 17 1/2" deep, rack mounting adaptors included.
(See Figures 1-1. and 2-1.)
AMBIENT OPERATING TEMPERATURE: -10°C to +50°C.
POWER SWITCH: OFF, RF OFF, RF ON.
POWER INPUT: 105 to 125 VAC 50-65Hz, approximately 150VA.
210 to 250 VAC optional, 400 Hz operation on special order.
WEIGHT: 45 lbs.

FIG. 2-1

DIMENSIONAL OUTLINE

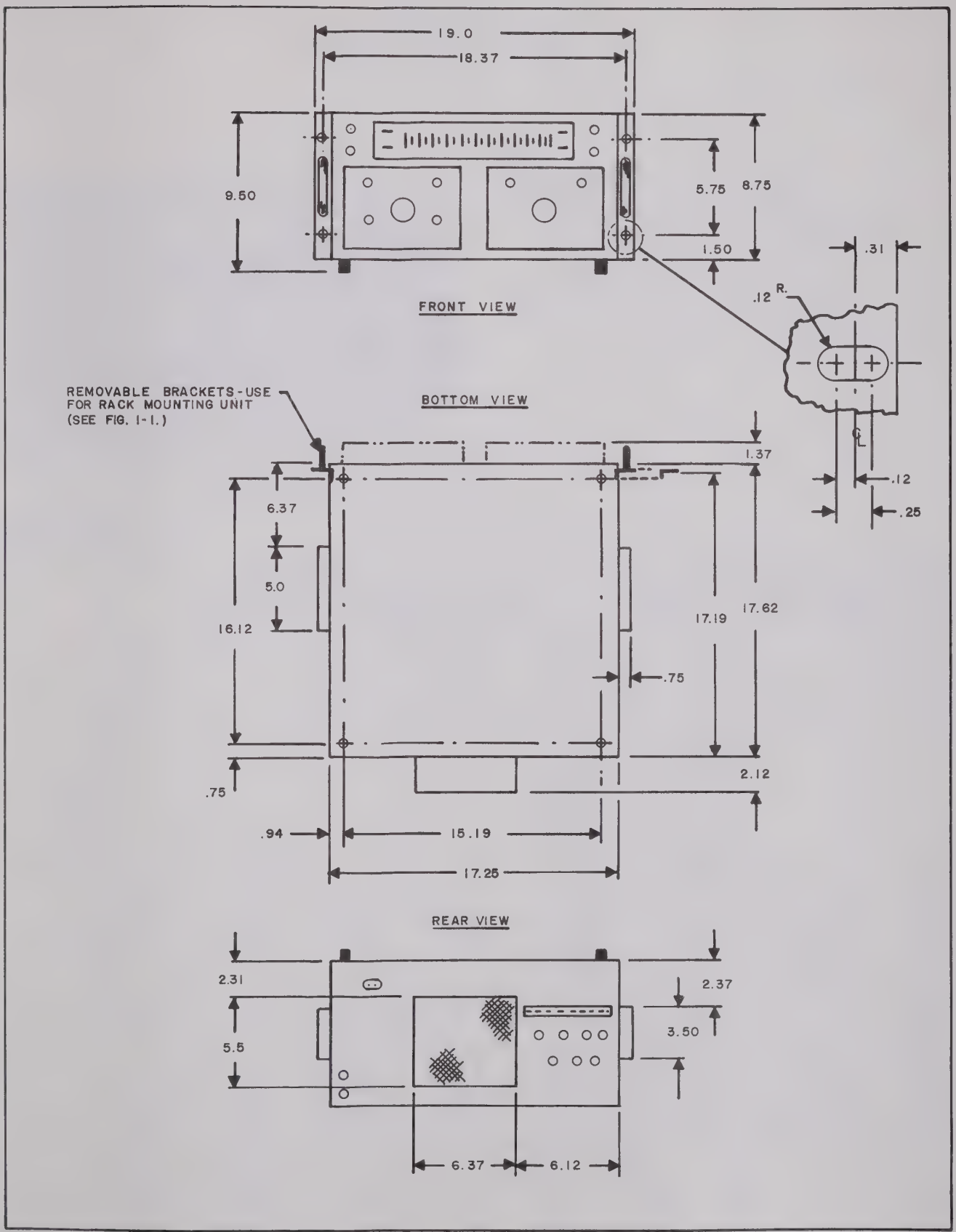
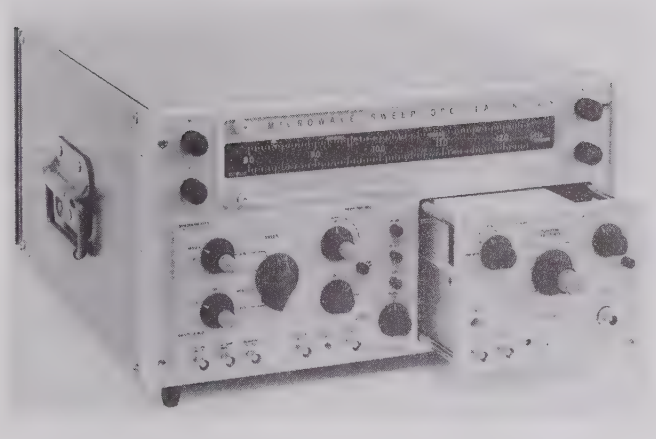


TABLE 2-1

MICROWAVE SWEEP OSCILLATOR

Model 221



Oscillator Mainframe With Plug-In

Accessories:

Model 200 Storage Enclosure
" 201 Remote Freq. Control
" 202 Multi-Band Sweep Control
" 203A Calibration Unit

Model 221 System 1 - 1-12.4 GHz Sweep System

PLUG-IN OSCILLATORS

	GRID LEVELED				DIODE LEVELED			
		Internal directional detector				Internal directional detector		
		Without	With			Without	With	
Frequency Range (Gc)	Min. Power* Output (mW)	Model	Model	Leveled Power Variation (dB)	Min. Power* Output (mW)	Model	Model	Leveled Power Variation (dB)
0.2-0.4	-	-	-	-	20	H24MD	-	-
0.25-0.5	-	-	-	-	50	H25MD	-	-
0.35-0.7	-	-	-	-	100	H37MD	-	-
0.4-1.2	-	-	-	-	20	H41MD	-	-
0.5-1.0	-	-	-	-	100	H51MD	-	-
0.5-1.0	30	H51B	-	-	15	H51DB	-	-
1-2**	-	-	-	-	40	H102SD	H102SDL	±0.3
1-2	100	H102	H102L	±0.3	60	H102D	H102DL	±0.3
1.4-2.5	100	H142	H142L	±0.3	60	H142D	H142DL	±0.3
1.7-4.2	-	-	-	-	15	H204DA	H204DLA	±0.5
2-4**	-	-	-	-	20	H204SD	H204SDL	±0.5
2-4	80	H204	H204L	±0.5	40	H204D	H204DL	±0.5
3.5-6.75	40	H356	H356L	±0.5	25	H356D	H356DL	±0.5
3.7-8.3	-	-	-	-	8	H408DA	H408DLA	±0.5
4-8	30	H408	H408L	±0.5	20	H408D	H408DL	±0.5
7-11	25	H711	H711L	±0.5	10	H711D	H711DL	±0.5
7-12.4	25	H712	H712L	±1.0	10	H712D	H712DL	±1.0
8-12.4	50	H812	H812L	±0.75	25	H812D	H812DL	±0.75
10-15.5	20	H1015	-	-	-	-	-	-
12.4-18	40	H1218	-	-	-	-	-	-
18-26.5	20	H1826	-	-	-	-	-	-
26.5-40	5	H2640	-	-	-	-	-	-

**All-Solid State

*Value indicated for units without internal directional detector, 1dB less with internal directional detector

SECTION 3-0.
OPERATION

3-1. INTRODUCTION. The Model 221 Microwave Sweep Oscillator is a flexible voltage controlled microwave signal source suitable for both swept and CW measurements. The frequency range is covered by a series of plug-in Oscillator Units. Each Oscillator Unit is furnished with a calibrated scale to be mounted on the Basic Unit when the Oscillator is plugged into the Basic Unit. When the Oscillator Unit is not in use, the scale should be mounted on the posts provided along side of the Oscillator Unit and retained on these posts with the screws furnished.
For schematic diagrams, component layout diagrams, specifications and parts list for the Oscillator Unit, see applicable Oscillator Unit Instruction Manual. The following paragraphs describe the controls and various modes of operation of the Model 221.

3-2. POWER CONTROL. When the POWER switch is turned to RF ON the STBY light will go on and:

a. Filament power will be applied to the microwave tube.

b. All other circuitry will be operative except that no voltages are applied to the helix and the anode of the BWO, or to the anode and the injection electrode of the VTM.

After 60 seconds the STBY light will go off and the RF ON light will go on and the equipment is ready for full operation. If the POWER switch is initially turned to the RF OFF position and allowed to remain in this position for 60 seconds, RF output will come on immediately when POWER switch is turned to the RF ON position.
If the POWER control switch is turned to RF OFF the high voltage will be removed from the microwave tube, however, the filament of the microwave tube will remain on. The RF output will be immediately restored when the POWER control is switched to RF ON.

3-3. SWEEP MODE SELECTOR. This control is located in the center of the left hand panel and is the main function selector for the equipment. The left hand positions are sweep modes and the right hand positions are CW modes.

3-4. EXTERNAL SWEEP MODE. In the EXT position, the Sweep Oscillator can be swept by means of an external sweep signal. The sweep signal can be introduced at the EXT SWP INPUT terminal where zero to +20 volts will sweep the RF frequency from the low limit to the high limit. This input is directly coupled and can be used for remote frequency programming.
In addition, while in the EXT position, a potentiometer (10K) can be connected at the rear of the sweeper and thereby manually control the frequency by means of the remote potentiometer. The output of this potentiometer is combined with the electrical input signal at the front panel SWEEP INPUT connector through an operational amplifier so that the resistance programming can be used together with an external sweep signal for complete flexibility in remote frequency sweeping or programming.

NOTE: In the following paragraphs, the "video displays" described refer to the patterns which appear on an oscilloscope when applied in circuits such as those shown in Figures 5-1., 5-3., and 5-5. (see Sections 5-0. to 5-12.)

3-5. F1-F2 MODE. In the F1-F2 mode the RF frequency sweeps from the F1 control frequency to the F2 control frequency. Normally the low frequency limit is set by the F1 control and the high frequency limit is set by the F2 control. This yields a low to high frequency sweep. In addition, the F1-F2 controls can be crossed over each other, thus providing a high to low frequency sweep.
The two (2) markers are controlled by the M1 and M2 controls and are continuously adjustable over the entire frequency range. The amplitude of the markers are adjustable by use of the MARKER AMPLITUDE control, from zero to

the full display amplitude. The markers are video signals generated within the sweeper and are introduced into the leveling system so that they appear as a dip in RF amplitude similar to a frequency meter dip. The markers can be removed from the amplitude display by means of a switch on the rear panel of the sweeper. This is described in paragraph 3-19. Internal Marker On/Off.

3-6. M1-M2 MARKER SWEEP MODE (EXPANDED SWEEP). The markers can also be used to select a portion of the range swept in the F1-F2 mode by positioning the two markers on either side of the portion to be expanded. The sweep mode selector is then placed in the M1-M2 position and the range between the markers is now displayed on the full width of the CRT.

3-7. SYMMETRICAL SWEEP. The symmetrical sweep mode is used where the description of the measurement is more conveniently made in terms of a center frequency and a bandwidth about that center frequency. For this type of display the sweep mode selector is set in the SYM M1 position and the SYMMETRICAL SWEEP WIDTH control, located in the center of the right hand panel, is used to set the total sweep width. It should be noted that the symmetrical M1 mode can also be used as an expansion on the F1-F2 mode by setting the M1 marker at the center of the portion of the F1-F2 display to be expanded. The symmetrical mode is particularly convenient for making narrow bandwidth measurements since the symmetrical sweep width is calibrated to within 10% of the sweep width and is thereby substantially more accurate than the markers for this type of measurement. The sweep width is calibrated in convenient steps from approximately 0.1% to 100% of the sweep range of the particular plug-in Oscillator Unit. In the maximum CW position, the concentric control of the sweep width selector is activated and allows the operator to continuously cover the full range of sweep width with one turn of the control.

3-8. SYMMETRICAL CENTER FREQUENCY SELECTOR. When the SWEEP/CW control is in the SYM position, the center frequency of the RF sweep presentation can be selected to be the frequency of the M1 indicator or a center frequency determined at a remote location. In the REMOTE position, an external potentiometer (10K) connected at the rear of the sweeper will determine the center frequency. If a number of different center frequencies are required, an external switch or push button control can select from a number of resistor dividers or potentiometer settings. The sweep width and sweep rate are set by the normal front panel controls.

3-9. CW MODE SELECTOR. With the equipment operating in the F1-F2 mode, the M1 or M2 marker can be positioned at particular frequencies by setting the marker coincident with the point observed on the display. When the SWEEP/CW control is placed in the M1 or M2 position, the RF output frequency will be at the point previously observed on the display. In addition, the four (4) indicators (M1, M2, F1 and F2) can be set at any arbitrary combination or sequence of frequencies and the RF frequencies can be selected by positioning the SWEEP/CW selector in the M1, M2, F1 or F2 position.

3-10. SWEEP TIME SELECTOR. This control permits selection of sweep time periods from 100 seconds to 0.01 seconds per sweep. This is accomplished with the decade switch selector operating with the concentric 10 to 1 single turn control to provide continuous adjustment over the full range of sweep speeds. The front panel values indicated at each position of the sweep time selector is obtained with the concentric control in the maximum CW position (CAL). One tenth of this value is obtained with the concentric control in the maximum CCW position.

3-11. MANUAL SWEEP. The maximum CCW position of the SWEEP TIME selector sets the equipment in the manual sweep mode. In this mode, the internal sweep generator is disabled and an output from the concentric SWEEP TIME control is substituted. As the concentric control is turned from its full CCW position to its full CW position, the RF frequency is varied between the lower and upper frequency limits of the SWEEP/CW control selector.

3-12. SWEEP TRIGGERING SELECTOR. The INT. position sets the sweep generator in the recurrent mode. In the LINE position, the sweep is triggered by line frequency for the 0.01 SEC position of the sweep time selector only. An external trigger signal can be used in the EXT position and a single sweep can be initiated by the MANUAL TRIGGER button in the MAN position of the selector switch.

3-13. AMPLITUDE MODULATION SELECTOR. Provides for the selection of an internally generated 1000Hz square wave or an external signal for amplitude modulation. The square wave frequency is adjustable about 1000Hz by means of the concentric control.

3-14. RF LEVELER. In the INT position, an internal directional coupler and detector are included in the closed loop feedback leveling system to provide a constant RF power level as the RF frequency is swept over its range. The RF LEVEL control sets the maximum level of the RF power across the band. In those portions of the band where there is sufficient RF power, the output will be leveled. In those portions of the band where there is insufficient RF power out of the microwave tube, the output will be unleveled and the UNLEVELED indicator will light. The operator can therefore set the RF level so that a leveled output is obtained across the entire frequency range of the unit, or he can set this control to obtain a higher leveled output over a portion of the range where higher RF power is available. The minimum power output of the BWO usually occurs at the low end of the frequency range. Therefore, if the RF level control is adjusted for leveled operation at the low end frequency, the RF output will be equal to the minimum power output of the BWO while sweeping over the entire frequency range.

3-15. EXTERNAL CRYSTAL LEVELING. The leveling system can be operated with an external directional coupler and crystal detector to provide the leveled RF output at the load instead of the front panel output terminal. This method of operation eliminates frequency sensitive attenuation in long transmission lines connecting the Sweep Oscillator to the load. The external directional coupler should be connected as close as possible to the load and the output of the crystal detector should be connected to the EXT DETECTOR INPUT terminal.
The output from the crystal detector should be approximately 50 millivolts for typical operating levels. Typical operating levels can be obtained with a 10dB directional coupler and standard crystal detectors. The output of the crystal detector must be negative and the GAIN control should be adjusted for the particular crystal detector and directional coupler to meet the stability requirements of the feed back loop. With the RF LEVEL control set in its maximum CW position, the GAIN control should be adjusted to cause leveling to start at the maximum RF power level within the total frequency range.

3-16. POWER METER LEVELING. Using an external directional coupler, the leveling loop is completed by connecting the thermistor mount of a power meter to the decoupled arm of the directional coupler and connecting the recorder output of the power meter to the EXT DETECTOR INPUT terminal on the sweeper. The recorder output of the power meter must be a negative signal. Satisfactory op-

eration can be achieved using the HP431B Power Meter or equivalent together with a 10dB directional coupler. The front panel GAIN control (next to the EXT DETECTOR INPUT terminal) should be turned to its maximum CCW position. Power level can now be controlled by both the RF LEVEL control of the sweeper and the range switch of the power meter. The power meter itself will indicate the leveling loop performance and the magnitude of leveled power. As the range switch of the power meter is set at lower values, the total gain in the leveler feedback loop is increased and a point will be reached where the loop will oscillate. In order to obtain stable operation at these low power settings of the power meter, the front panel GAIN control should be readjusted. Square wave modulation can be applied in the power meter leveled mode; however, the leveling action is such as to maintain the average power out constant and not the peak power. As a result, for the 50% duty cycle of the internal square wave, the peak power will be twice the value indicated by the average reading power meter. RF DURING RETRACE is automatically disabled for power meter leveling.

3-17. SWEEP OUTPUT AMPLITUDE. A SWEEP OUTPUT AMPLITUDE control located on the rear panel is used to adjust the amplitude of the sweep output. This control permits adjustment of the horizontal display width for oscilloscopes which do not have a horizontal gain control.

3-18. RF DURING RETRACE ON/OFF. In the OFF position of this switch, the RF power is turned off during retrace and provides a zero power reference base line for the RF display. In the ON position, RF power is on during retrace as well as forward trace. This position is useful for chart recorder operation because it avoids large amplitude changes and rapid travel of the pen drive mechanism at the beginning and end of the sweep. It is recommended that the RECORDER PEN LIFT provision be used to lift the pen during retrace to avoid the superposition of the forward and retrace sweeps.

3-19. INTERNAL MARKER ON/OFF. In the ON position, the markers are displayed as a dip in RF power. In those applications where the change in RF level causes undesirable effects in the measurement, the markers can be removed from the RF power display by placing this switch in the OFF position. The markers are then still available as video signals at the rear panel INTERNAL MARKER OUTPUT for display on a second trace of a dual trace oscilloscope.

3-20. HELIX (HV) SUPPLY BANDWIDTH. In normal operation of the sweeper, the Helix Supply operates in its wide bandwidth mode for all swept modes. When the SWEEP/CW control is switched to the CW modes, the bandwidth of the Helix Supply is reduced. This reduction in bandwidth results in a decrease in the noise and ripple at the output of the Helix Supply. The reduction in bandwidth also has the effect of reducing the response time of the Helix Supply and therefore it cannot be swept rapidly when in the narrow band mode.
If the operator chooses to operate in the CW mode with the Helix Supply in the wide band mode, the jumper between the terminals marked N.C. should be removed from the rear panel terminal board. Alternately, if the operator chooses to operate in the narrow band mode of the Helix Supply when the front panel controls are set in either
SWEEP/CW----------EXT
SWEEP TIME (SEC)---MAN, or 10 SEC
then a jumper should be placed across the terminals marked N.O. on the rear panel terminal board.

3-21. REMOTE FREQUENCY PROGRAMMING. With the sweep mode selector in the EXT position, a potentiometer (10K) can be connected via the rear panel EXT SWEEP MODE-REMOTE FREQ CONTROL terminals, to control the RF frequency as a function of potentiometer setting.
A multiple number of remotely set frequencies can be achieved by the use of

switching to select from a number of preset potentiometers. In addition, an electrical signal can be simultaneously introduced into the front panel EXT SWP. INPUT connector to be operationally added to the voltage supplied by the potentiometer. In this way, all front panel frequency control functions can be duplicated remotely.
For additional information regarding this mode of operation, refer to paragraphs 3-4. External Sweep Mode, 3-8. Symmetrical Center Frequency Selector and 3-24. Sweep Input.

3-22. INPUTS. The following electrical inputs are designed for use with external equipment. Precautions should be taken that no input voltage exceeds ±20 volts unless specifically stated in this manual or approved by the manufacturer.

3-23. EXTERNAL AM INPUT. The RF output can be amplitude modulated by signals applied to the front panel EXT AM INPUT connector and with the AMPLITUDE MOD selector in the EXT position. This modulation can be used in any of the sweep or CW modes.
Rise times are 1.0 microsecond unleveled and approximately 10 microseconds leveled.

3-24. SWEEP INPUT. A signal voltage of zero to 20 volts applied to the front panel EXT SWP INPUT connector will change the output RF frequency as a linear function of the input signal. Zero volts corresponds to the low limit and +20 volts corresponds to the high limit. If the combination of the sweep input signal and a remote frequency input from an external potentiometer connected at the rear add up to a control signal demanding a frequency above or below the ratings of the unit, an automatic clamp circuit becomes operative and limits the voltage applied to the microwave tube.
The response time is 200 microseconds for full sweep with increasing frequency and 2 milliseconds for full sweep with decreasing frequency.

3-25. TRIGGER INPUT. A 10 volt negative signal applied to the EXT TRIG INPUT will initiate the sweep when the SWEEP TRIGGERING selector is in the EXT position. The trigger signal should have a minimum duration of 1 microsecond.

3-26. AM PULSE INPUT. For proper operation place the RF LEVELER in the OFF position and the SWEEP/CW switch in a CW position. Adjust the RF LEVEL control CCW until the RF output power goes to zero and leave the RF LEVEL control at this setting. Signals applied to the AM PULSE INPUT are capacitor coupled to the grid of the BWO and are used to obtain rapid rise and fall time, pulsed RF OUTPUT signals. For pulse widths up to 5 microseconds, signals applied to this input will provide the desired output. For pulse widths wider than 5 microseconds, where the 0.1 microsecond rise and fall time is required, the pulse signal should be applied simultaneously to the AM PULSE INPUT and the EXT AM INPUT. In this way, arbitrarily wide pulses with fast rise and fall times can be obtained. The CW mode is recommended for operation with the AM PULSE INPUT because the BWO grid is capacitively coupled to ground when a 50 ohm generator is connected to this terminal. Although slow sweep speeds are possible, the AC component of the helix to cathode voltage is coupled to the cathode-to-grid circuit and will add AM as the unit is swept.

3-27. FM INPUT. This input can be used to direct couple wideband signals to the helix of the BWO to obtain rapid frequency modulation of the RF output. The frequency response is DC to 5 MHz. An emitter follower is used to couple the input signal to the helix of the BWO and a 4.7K resistance appears in shunt with the FM INPUT connection. The signal levels applied to this input should not exceed ±20 volts. The modulation sensitivity (MHz/Volt) will be different for each frequency range and will depend on the particular portion of the band. A rule-of-thumb sensitiv-

ity is 0.05% of the operating frequency per volt.
This input is not applicable to plug-in Oscillator Units using a voltage tunable magnetron (VTM).

3-28. EXTERNAL DETECTOR INPUT. This input is used in accordance with the instructions given in paragraphs 3-15 and 3-16 of this manual. It is used to complete the feedback path when the equipment is in an externally leveled mode.

3-29. EXTERNAL SWEEP MODE - REMOTE FREQUENCY CONTROL. An external potentiometer (10K) can be connected at the rear panel terminal board to operate the sweeper as described in paragraphs 3-4. External Sweep Mode, 3-8. Symmetrical Center Frequency Selector and 3-24. Sweep Input.

3-30. *REMOTE LEVEL CONTROL. An external potentiometer (10K) can be connected at the rear panel REMOTE RF LEVEL terminals to replace the front panel RF LEVEL control. When the external control is used, the OFF jumper must be removed and placed in the ON position, and the front panel RF LEVEL control must be maximum CW.

3-31. OUTPUTS.

3-32. RF OUTPUT. The minimum RF output is specified in the instruction manual for each of the plug-in Oscillator Units. The operator can, however, increase the RF output in the unleveled mode to as much as 10dB above the specified minimum output. The maximum power will depend on the particular microwave tube, and for the BWO the maximum will usually occur in the upper half of the frequency range.

3-33. SWEEP OUTPUT. The signal used to drive the horizontal deflection system of the display oscilloscope is provided at the SWEEP OUTPUT connector. The amplitude of this signal is independent of the setting of the sweep limit. However, for convenience in use with the oscilloscope, a horizontal gain control is available on the rear panel and should be used as described in paragraph 3-17. Sweep Output Amplitude.

3-34. BLANKING OUTPUT. The blanking signal is a 20 volt, negative pulse, with a time duration equal to the sum of the retrace time and dwell time. This signal is available at the front panel BLANKING OUTPUT connector.

3-35. INTERNAL MARKER OUTPUT. The video marker signals are available at a BNC connector on the rear panel and can be used as described in paragraph 3-19. Internal Marker On/Off.

3-36. RECORDER PEN LIFT. A set of relay contacts are available at the rear panel and are intended for use with recorders equipped to raise the pen in response to an open circuit. The relay contacts are opened during the time interval between the end of one sweep and the beginning of the next sweep for 1 sec. and 10 sec. sweep time modes.

3-37. PROPORTIONAL SWEEP OUTPUT. This signal is available at the rear panel and is a voltage analog of the output frequency. It has a constant linear relationship with the output frequency and is independent of sweep width or sweep rate.

* For grid leveled oscillator units only.

SECTION 4-0.
PRINCIPLES OF OPERATION

4-1. GENERAL BLOCK DIAGRAM. Figure 4-1. shows an overall block diagram of the Model 221 Microwave Sweep Oscillator. The frequency of the RF output is controlled by the helix-to-cathode voltage applied to the BWO. The amplitude of the RF output is controlled by the voltage applied between the grid and cathode of the BWO. A portion of the RF output is sampled in the directional coupler, detected and fed to the LEVELING AMPLIFIER. The leveling amplifier compares the amplitude of the detector output with a reference voltage and feeds a correction signal to the grid of the BWO through the grid supply so that the detector output remains equal to the reference voltage. As the RF frequency is varied, the leveling loop operates continuously to maintain the detector output constant independent of the RF frequency. The amplitude variation of the RF at the front panel connector will therefore depend only on the transfer characteristics of the directional coupler-detector combination.

Provision is made for the use of an EXTERNAL RF DETECTOR and DIRECTIONAL COUPLER. In this mode of operation the output of the external detector is connected to the leveling amplifier input.

To AMPLITUDE MODULATE the RF output as the RF frequency is swept, a modulating signal is used in place of the reference voltage feeding the leveling amplifier. The RF blanking during retrace, square wave modulation, frequency marker signals, and external AM input signals are used to amplitude modulate the RF output in this manner.

In the UNLEVELED MODE of operation, the voltage applied to the grid of the BWO is manually set by the front panel RF level control. Amplitude modulation of the RF output in the unleveled mode is accomplished by feeding a modulating signal directly to the grid of the BWO.

Oscillator Units equipped with a VTM instead of a BWO operate in a manner similar to that described above with the exceptions that the VTM anode serves the same function as the BWO helix and the RF output amplitude is controlled by a diode modulator.

The RF frequency range is covered by sweeping the output voltage of the HELIX SUPPLY. The SWEEP GENERATOR drives the helix supply with the required waveforms as determined by the settings of the front panel controls. In addition, the sweep generator supplies synchronous signals for sweep output, retrace blanking and, at the slower sweep speeds, recorder pen lift during retrace.

The internally generated SWEEP WAVEFORM can be triggered by an external electrical trigger input or by the manual trigger switch. External control of the sweep waveform is provided by introducing an external electrical signal or by connecting an external potentiometer for remote resistance programming.

The MARKER GENERATOR combines the sweep signal and the voltages at the output of the marker controls to provide a marker signal when the output RF frequency corresponds to the marker indicator position on the main frequency dial.

4-2. SWEEP GENERATOR. Fig. 4-2 shows a block diagram of the sweep waveform generator. The AMPLIFIER combined with its feedback capacitor and input resistor, forms an INTEGRATOR. The forward trace time constant is equal to R2 x C and is variable with resistance R2. The retrace time constant is equal to R1 x C. In the recurrent mode the integrator output increases until a voltage level is reached such that the UPPER LIMIT COMPARATOR causes the BINARY to change state and apply a large negative voltage through R1. This change causes the direction of current flow in the capacitor to reverse and the output voltage de-

creases. The integrator output voltage decreases until a voltage level is reached such that the LOWER LIMIT COMPARATOR causes the binary to change to its original state which applies zero volts to R1. The constant current flowing through R2 causes the direction of current flow in the capacitor to change and the output voltage increases. In the triggered mode, the lower limit comparator is disconnected from the input to the binary and the integrator output is approximately zero volts. When a trigger pulse is applied to the binary, the sawtooth waveform is generated as it was in the recurrent mode. When it returns to zero, it will remain there until the next trigger is applied.

A DWELL TIME GENERATOR introduces a time delay between the end of the retrace and the beginning of the next sweep. This is accomplished by using the binary signal at the end of retrace to trigger a monostable multivibrator called the dwell generator. The output of the dwell generator is combined with the normal binary output in an OR CIRCUIT feeding the integrator. In this manner, the dwell generator can add to the blanking interval before the initiation of the next sweep.

The HOLD OFF CIRCUIT is used to desensitize the binary during the retrace period. This prevents trigger signals from restarting the forward trace while the normal retrace cycle is still active.

The SWEEP ON INDICATOR circuit examines the state of the binary to determine if the sweep is in the forward state. When the sweep is in the forward state the SWP ON indicator lamp will light.

A summary of the SWEEP GENERATOR WAVEFORMS is shown in Fig. 4-3 illustrating the relationships among the various circuits on a time basis.

4-3. SWEEP AMPLIFIER. F1-F2 or M1-M2
The sweep waveform required at the input to the helix supply is one where the minimum voltage and maximum voltage of the waveform are adjustable and correspond to the F1 and F2 positions of the frequency indicators of the main dial. The circuitry used to accomplish this is shown in Fig. 4-4. AMPLIFIER 2 inverts the input sweep waveform and displaces it so that its output is entirely negative and never becomes more positive than zero volts. The output of AMPLIFIER 2 is combined with the sweep waveform in the SUMMING AMPLIFIER 1 which provides the desired output sweep waveform. The minimum value of the output sweep waveform VF1 is proportional to the position of the F1 potentiometer and the maximum value of the output sweep waveform VF2 is proportional to the position of the F2 potentiometer.

The direction of sweep is from F1 to F2. In normal operation F1 is lower than F2, however, F1 can be made to be higher in frequency than F2 by cross-over of the F1 and F2 indicators. The output frequency will then sweep from the higher to the lower frequency.
The sweep waveform is also used to develop the frequency marker signals and is made available at the output of AMPLIFIER 4. A synchronous sweep waveform for driving the horizontal trace of an oscillographic display is provided at the output of AMPLIFIER 3. In the expanded M1-M2 sweep mode, the M1 and M2 potentiometers are used instead of the F1 and F2 potentiometers.

4-4. SWEEP AMPLIFIER, SYMMETRICAL M1 OR SYMMETRICAL REMOTE. In the symmetrical sweep mode the amplifiers of the waveform generator are interconnected as shown in Fig. 4-5. The sweep waveform is combined with the DC level from the M1 potentiometer in the HELIX SUPPLY AMPLIFIER. The amplitude of the sweep waveform is controlled by the VARIABLE GAIN AMPLIFIER 1. In this way, the center frequency is set by the position of the M1 potentiometer and the symmetrical sweep width is set by the gain of Amplifier 1.
The sweep waveform used to generate the frequency marker signal is provided at

the output of AMPLIFIER 4 which combines the DC level from the M1 potentiometer and the variable saw waveform in the same manner as in the helix supply amplifier.
A synchronous sweep waveform for driving the horizontal trace of an oscillographic display is provided at the output of AMPLIFIER 3.
The SYM CENTER FREQ selector is used to select the DC level from either the M1 potentiometer or a potentiometer located remotely. The REMOTE FREQ CONTROL potentiometer is connected to the equipment at the rear panel.

4-5. SWEEP AMPLIFIER, EXTERNAL MODE. The interconnection of the amplifiers in the waveform generator for the external mode is shown in Fig. 4-6. The external sweep signal is connected directly to the helix supply. The sweep waveform used to generate the frequency marker signal is provided at the output of AMPLIFIER 4. A synchronous sweep waveform for driving the horizontal trace of an oscillographic display is provided at the output of AMPLIFIER 3.

4-6. SWEEP AMPLIFIER CW MODE. There are four CW frequencies that can be selected by means of the SWEEP/CW selector switch. The four frequencies correspond to the settings of the F1, F2, M1 and M2 indicators on the main frequency dial. In addition to being a CW frequency setting, the M1 control can be used as a method of manual sweeping. That is, manual rotation of the M1 control will provide the same display as the electronically swept modes in that a synchronous sweep signal for driving the horizontal trace of an oscillographic display and frequency markers are provided. In this mode of operation, the amplifiers of the waveform generator are interconnected as shown in Fig. 4-7.

4-7. MARKER GENERATOR. The interconnection of the circuit elements of the marker generator is shown in Fig. 4-8. The difference between the instantaneous value of the sweep waveform and the DC level set by the M1 or M2 marker potentiometer is continuously calculated by the DIFFERENCE AMPLIFIER.
Over most of the sweep range the difference signal is large and will cause output 1 to be large and output 2 to be zero or output 2 to be large and output 1 to be zero. Under either of these conditions, the output of the AND CIRCUIT will be zero. In the range where the sweep waveform is approximately equal to the DC level from the marker potentiometer, output 1 and output 2 will be moving from maximum output to zero and from zero to maximum output, in opposite directions, as shown in Fig. 4-8a. Since the AND CIRCUIT will provide at its output the minimum of its instantaneous input values, the signal at its output will be a triangular waveform. The apex of the triangle occurs at the value of sweep signal which is exactly equal to the DC level from the marker potentiometer. The two marker channels are combined in an OR CIRCUIT to provide a composite marker signal for use in the frequency display.

4-8. LEVELING AMPLIFIER. Fig. 4-9 shows the block diagram of the leveling amplifier. The RF output amplitude is maintained constant by means of a closed loop system consisting of the leveling amplifier, grid supply and the BWO in the forward portion of the loop and the directional coupler and detector in the feedback network. The reference for this system is the DC level provided by the RF LEVEL potentiometer. If an external directional coupler and detector are used, the detector output must be negative and it can be introduced at the input to the leveling amplifier.
The internally generated marker signal can be used to modulate (decrease) the RF output amplitude and appears as a spike on the output display. The RF output amplitude level is determined by the setting of the RF LEVEL potentiometer (reference).
To AM MODULATE the RF output, the modulating signal is substituted for the DC reference voltage and the modulation

amplitude is controlled by the RF LEVEL potentiometer.
During retrace, a BLANKING SIGNAL is introduced to reduce the RF output to zero for base line reference in an oscillographic display.
In the UNLEVELED mode of operation, the output of the RF LEVEL potentiometer is open-loop connected to the BWO grid through the grid supply.
In all Oscillator Units equipped with a DIODE MODULATOR (identified with a D suffix in the model number) the forward portion of the loop includes the diode modulator instead of the grid control of the BWO. The signal from the leveling amplifier or the OPEN-LOOP MODULATOR is connected directly to the diode modulator instead of the grid supply. In order that the RF power be absolutely zero during retrace and during the off period of the internally generated square wave, both the blanking and the square wave signal are coupled to the BLANKING MODULATOR, which feeds the grid supply turning off the BWO for these types of signals. When an external POWER METER is used as the reference element in the leveling system, instead of a crystal detector, the stabilizing time constants in the leveling amplifier are changed in order to meet the feedback loop stability requirements. With the loop closed for power meter leveling, the response time of the leveling amplifier is limited primarily by the time constant of the thermistor mount in the power meter. This means that the sweep rates are limited to the region between 100 seconds per sweep to 10 seconds per sweep. In this mode of operation, the power in retrace automatically is switched on when the front panel control is placed in the power meter position.
Provision is made for the use of the internal SQUARE WAVE GENERATOR in the power meter leveled mode. The response time required to reproduce the square wave modulation is too short for the power meter leveling loop, and therefore, the average power of the square wave modulation is used as the reference for the feedback loop. Since the duty cycle is 50%, the peak power with square wave modulation will be twice the average power.

4-9. GRID SUPPLY. The grid supply is used to transform the DC RF amplitude control signal, referenced to chassis ground, to the grid of the BWO, referenced to the BWO cathode potential. The grid supply is therefore a DC to DC transformer and is shown in block diagram form in Fig. 4-10. The input signal is used to amplitude modulate a high frequency carrier generated by the OSCILLATOR. The modulated output is TRANSFORMER COUPLED to the DEMODULATOR which is used to demodulate the carrier signal and thereby restore the input DC level at the elevated cathode potential.

4-10. HELIX AND ANODE SUPPLY. Fig. 4-11 shows the block diagram of the helix and anode supplies used for the BWO.
The HELIX SUPPLY consists of a HIGH VOLTAGE, DC SUPPLY, a SERIES REGULATOR, and a HIGH GAIN HELIX AMPLIFIER (H) connected in a closed loop feedback system. The reference for this supply is the sweep signal provided by the waveform generator. Since the RF frequency vs. helix voltage characteristic for a BWO is not linear, a DIODE SHAPING NETWORK is incorporated in the feedback network of the closed loop helix supply to provide a linear relationship between the input voltage to the helix amplifier and the frequency of the RF output of the BWO. This linearizing network operates in the following manner. A portion of the output voltage appears across the diode network and as the output voltage increases, more diodes become forward biased. As each diode introduces its incremental current, the output voltage deviates from its value as would be determined by a simple linear relationship with the input sweep signal. By the suitable choice of resistors in series with the diodes, the helix voltage vs. sweep input voltage curve can be shaped to provide a linear relationship between the RF frequency and the input sweep voltage.

In operation of the sweeper in the end limit sweep modes, the maximum and minimum RF frequencies never exceed the values set on the main frequency dial. In the symmetrical mode however, it is possible to set the center frequency at the high frequency limit on the dial and then increase the symmetrical sweep width control to maximum. With the controls set this way, the maximum voltage will be well in excess of the high voltage capability of the instrument. To avoid this situation, a HIGH VOLTAGE CLAMP CIRCUIT is used to limit the maximum voltage of the helix supply. A LOW VOLTAGE CLAMP CIRCUIT is used to limit the helix voltage at the low frequency limit. The ANODE SUPPLY is a closed loop feedback regulator operating from the same high voltage, raw DC supply as the helix supply. A separate SERIES REGULATOR, HIGH GAIN ANODE AMPLIFIER (A) and REFERENCE CIRCUITS are used and the output voltage is adjusted for the particular BWO requirements.

4-11. COLLECTOR, FILAMENT AND AUXILIARY SUPPLIES. These supplies are shown in block diagram form in Fig. 4-12. Each of them consists of a RAW DC SUPPLY, SERIES REGULATOR and HIGH GAIN AMPLIFIER with its associated REFERENCE CIRCUITS.

4-12. PROTECTIVE CIRCUITS. A number of circuits have been incorporated in the Microwave Sweep Oscillator for the sole purpose of protecting the Microwave Tube from being damaged as a result of component failure in the equipment. Each protective circuit is designed to energize a relay and close a set of contacts which is used to trigger the power control circuitry and turn the entire equipment off.

4-13. HELIX OVERCURRENT (applies to BWO only). The helix current trip circuit consists of A11Q807 and A11Q808 and is located in the Oscillator Unit. It is set to trip when the current flowing to the helix exceeds the value specified by the BWO manufacturer.

4-14. ANODE OVERVOLTAGE (INJECTION ELECTRODE for VTM UNITS). The filament/anode trip circuit consists of A5Q6 and is set to trip when the voltage applied to the anode of the BWO (injection electrode of the VTM) exceeds the maximum value specified by the tube manufacturer.

4-15. FILAMENT OVERVOLTAGE. The filament/anode trip circuit consists of A5Q5 and A5Q6 and is set to trip when the DC voltage applied to the filament of the Microwave Tube is above the value specified by the tube manufacturer.

4-16. HELIX UNDERVOLTAGE (ANODE FOR VTM UNITS). A string of diodes consisting of A11R805, A11CR806, A11CR807 are connected between the output of the anode (injection electrode) and helix (anode) supplies so that the helix voltage cannot become negative with respect to the anode.

4-17. HIGH VOLTAGE INTERLOCK. An interlock connection is made in the plug-in Oscillator Unit so that if the Oscillator Unit is not plugged into the Basic Unit, the high voltage circuitry cannot be energized.

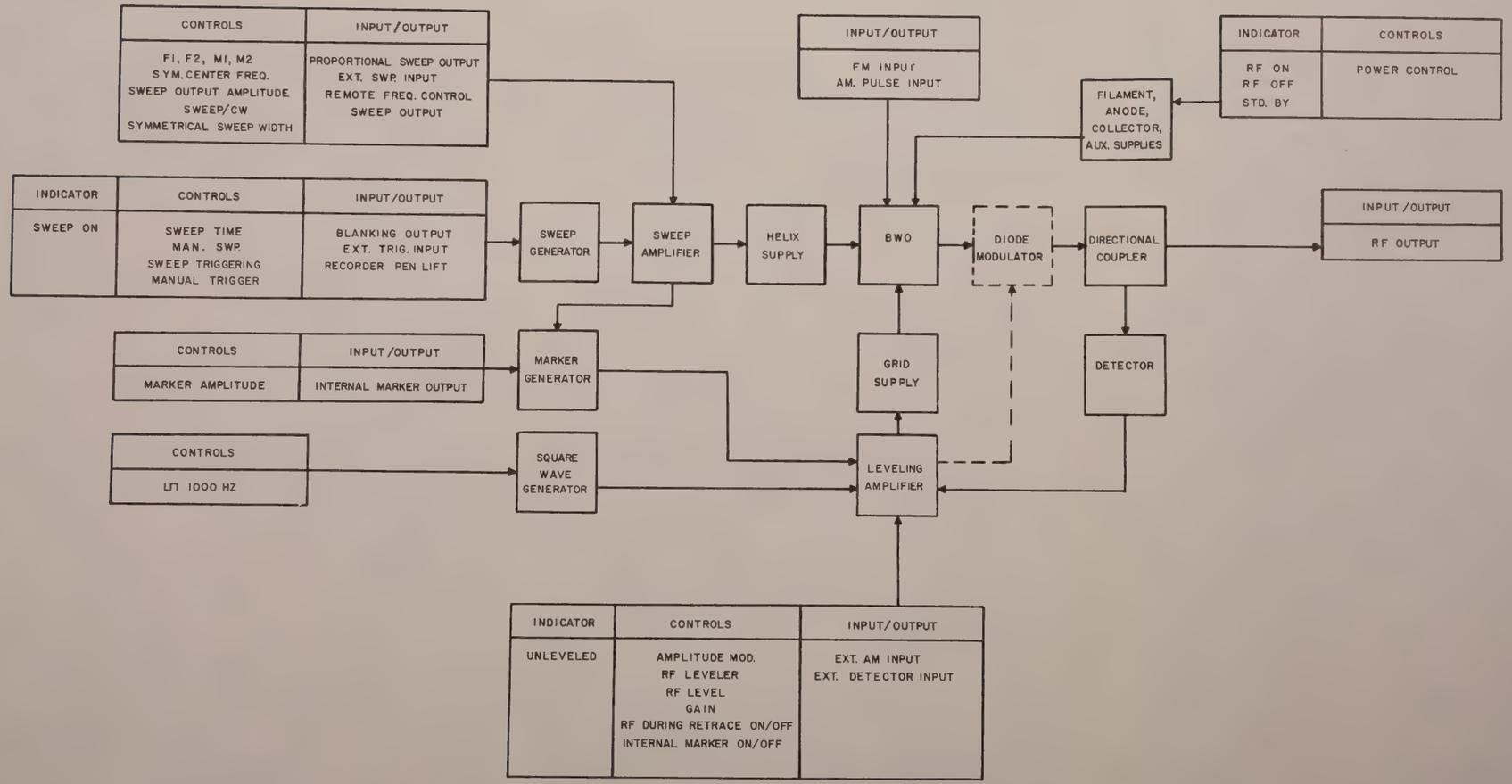


FIG. 4-1.
GENERAL BLOCK DIAGRAM
MODEL 221

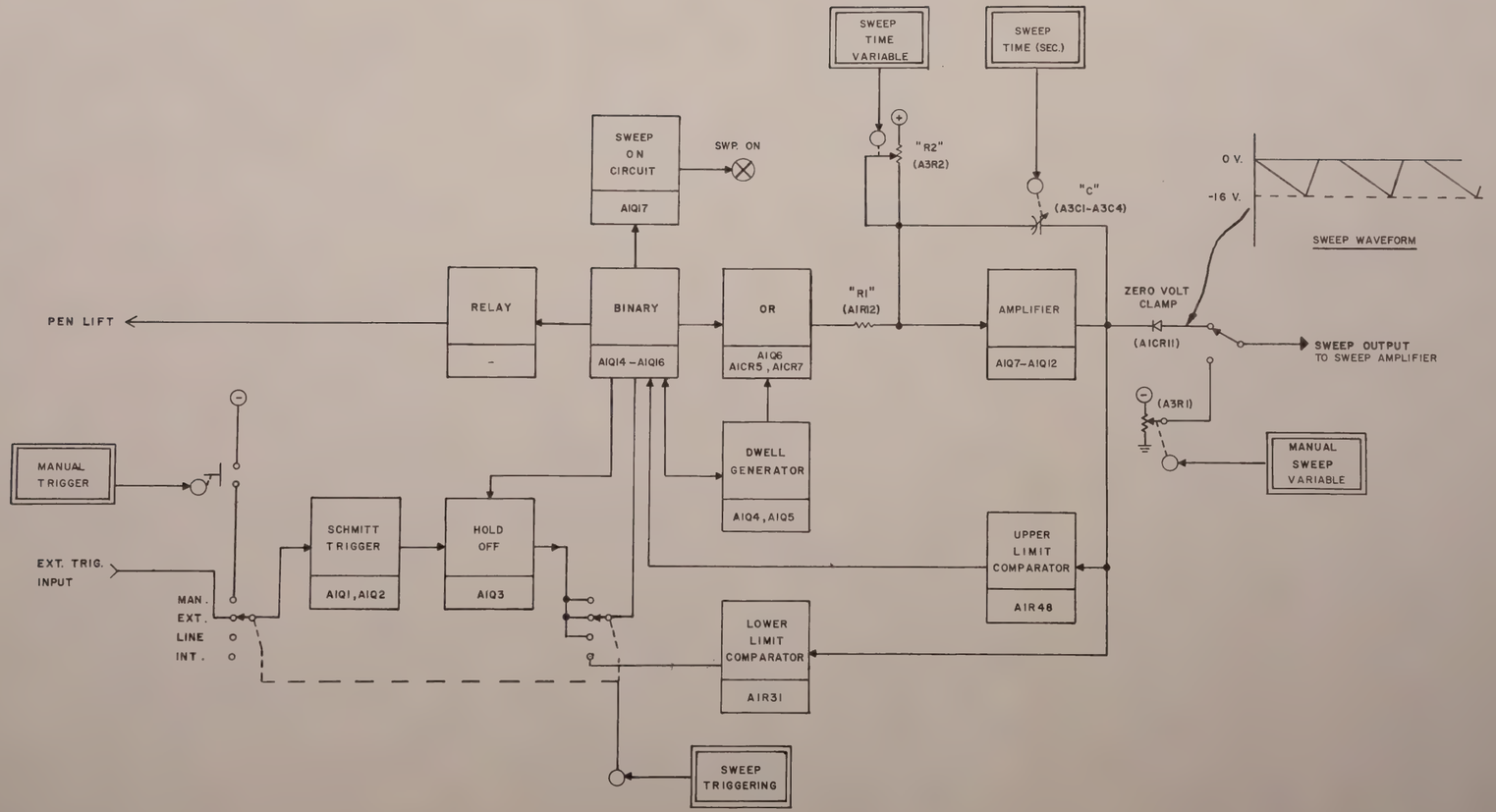


FIG. 4-2.
SWEEP GENERATOR
BLOCK DIAGRAM
MODEL 221

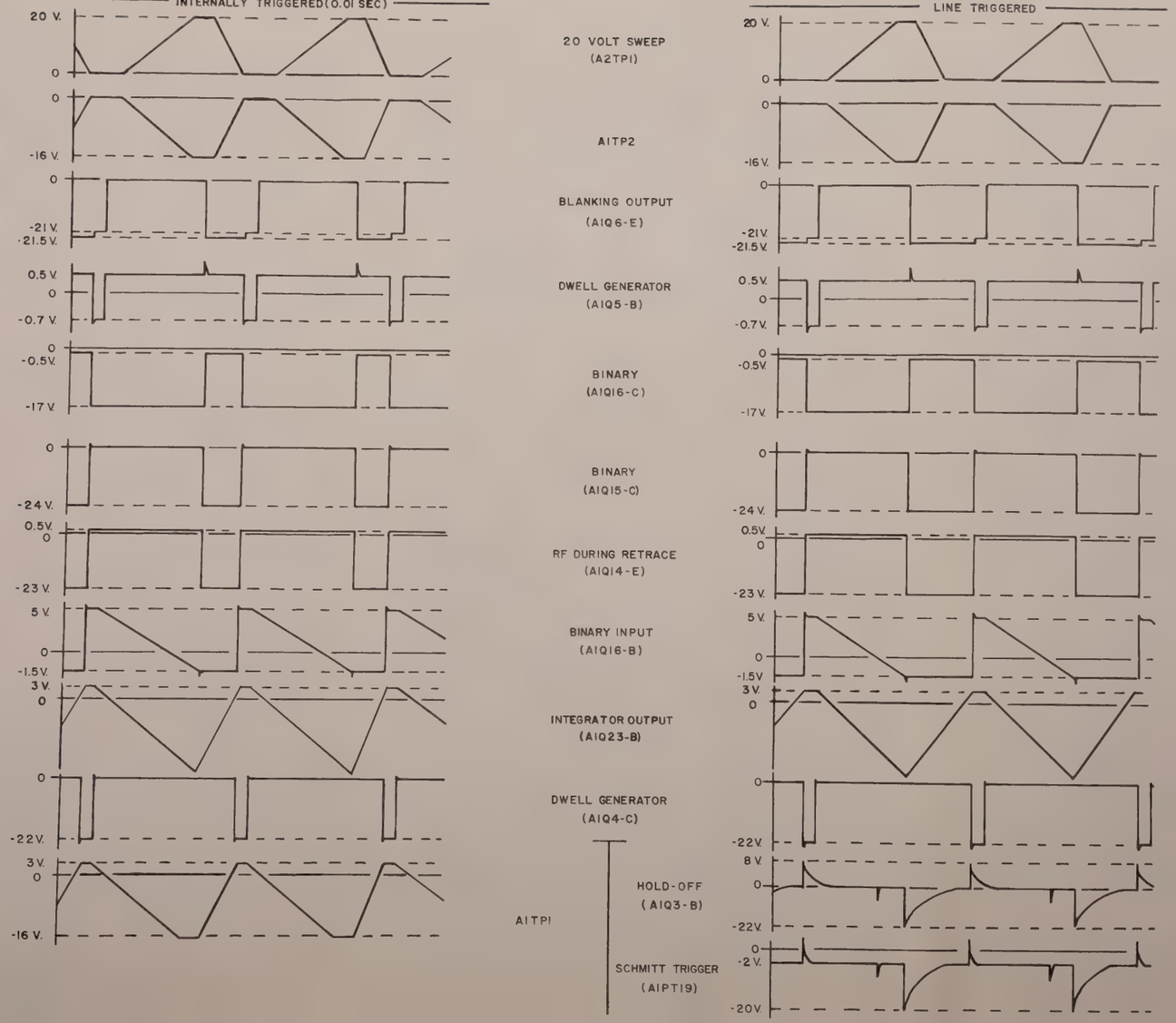


FIG. 4-3.
SWEEP GENERATOR WAVEFORMS
MODEL 221

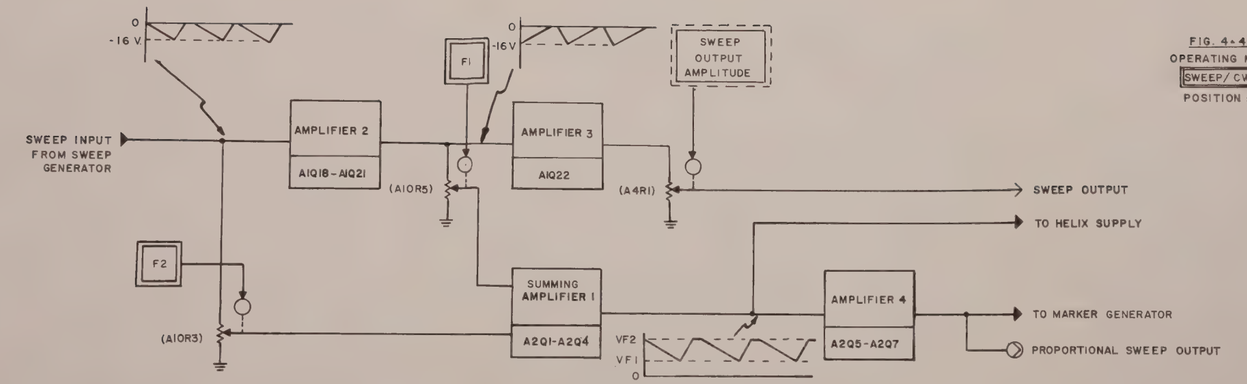


FIG. 4-4.
OPERATING MODE
SWEEP/CW
POSITION : F1- F2 or M1 - M2

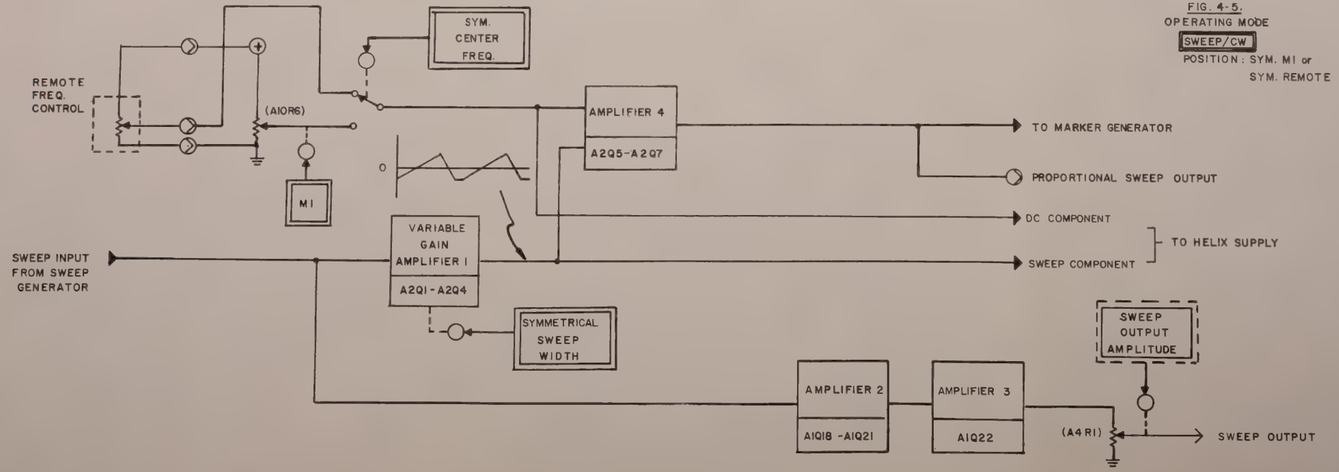


FIG. 4-5.
OPERATING MODE
SWEEP/CW
POSITION : SYM. M1 or SYM. REMOTE

FIG. 4-4 & 4-5.
SWEEP AMPLIFIER
BLOCK DIAGRAM
MODEL 221

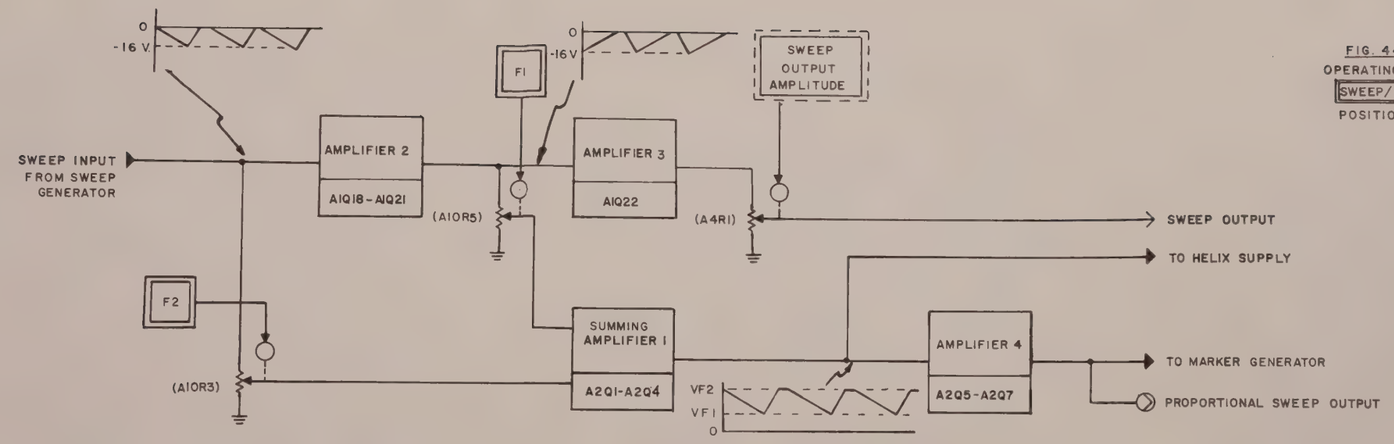


FIG. 4-4.
OPERATING MODE
SWEEP/CW
POSITION : F1- F2 or M1-M2

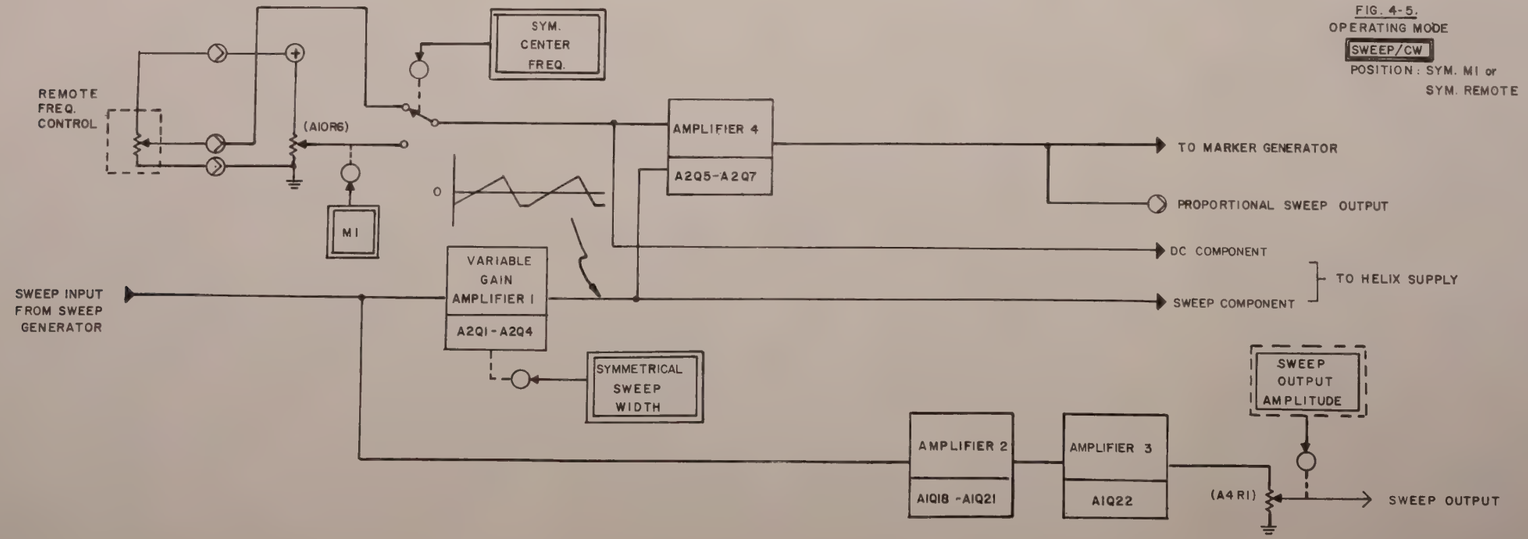


FIG. 4-5.
OPERATING MODE
SWEEP/CW
POSITION : SYM. M1 or SYM. REMOTE

FIG. 4-4 & 4-5.
SWEEP AMPLIFIER
BLOCK DIAGRAM
MODEL 221

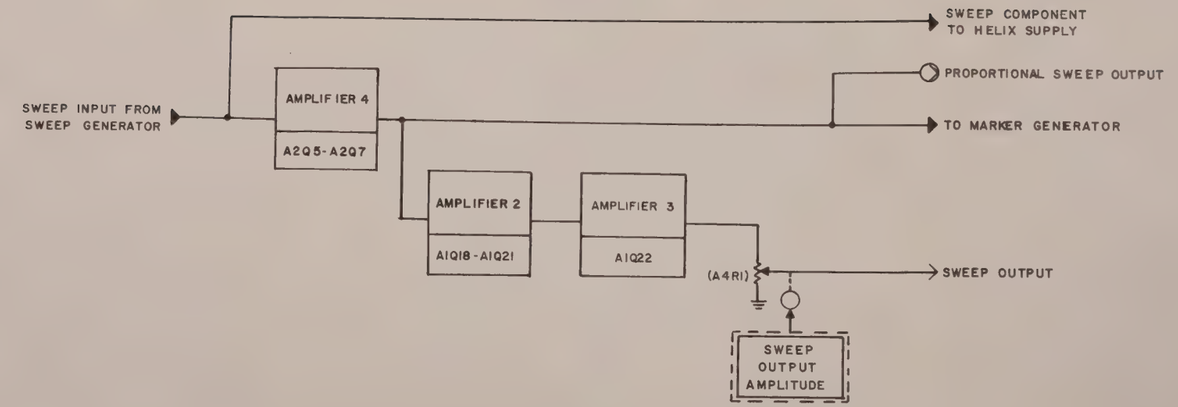


FIG. 4-6.
OPERATING MODE
SWEEP/CW
POSITION: EXT.

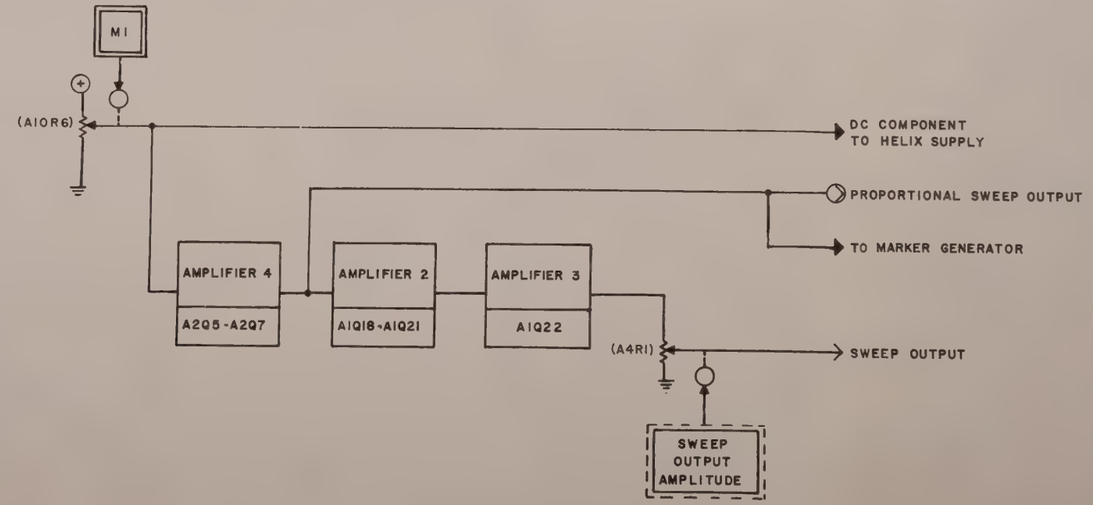
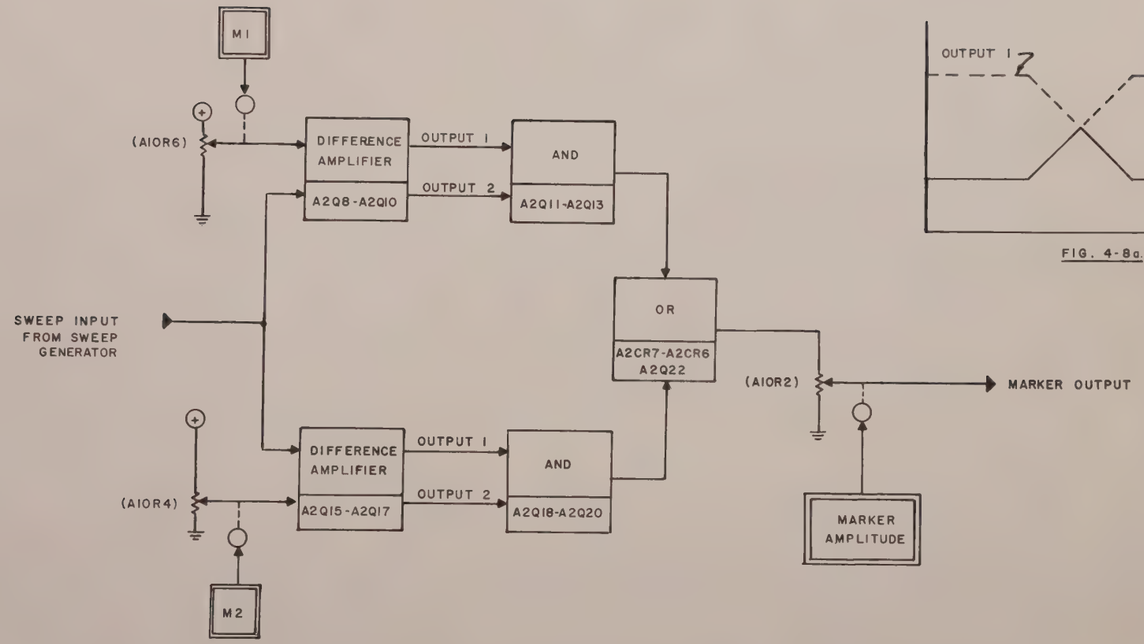


FIG. 4-7.
OPERATING MODE
SWEEP/CW
POSITION: CW

FIG. 4-6 & 4-7.
SWEEP AMPLIFIER
BLOCK DIAGRAM
MODEL 221



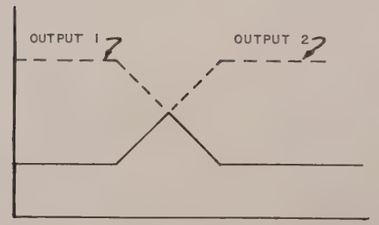


FIG. 4-8a.

FIG. 4-8.
MARKER GENERATOR
BLOCK DIAGRAM
MODEL 221

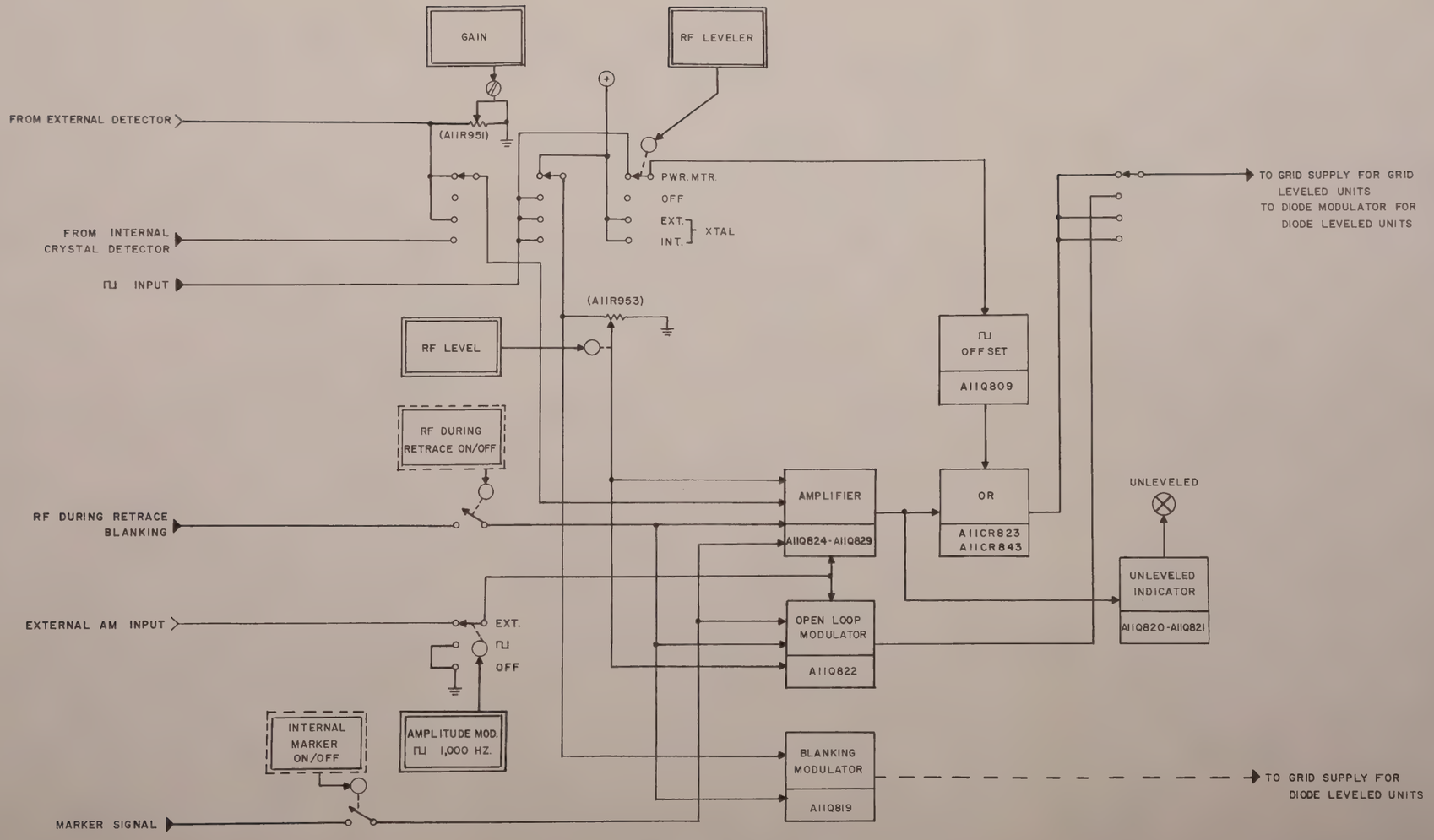


FIG. 4-9.
LEVELING AMPLIFIER
BLOCK DIAGRAM
MODEL 221

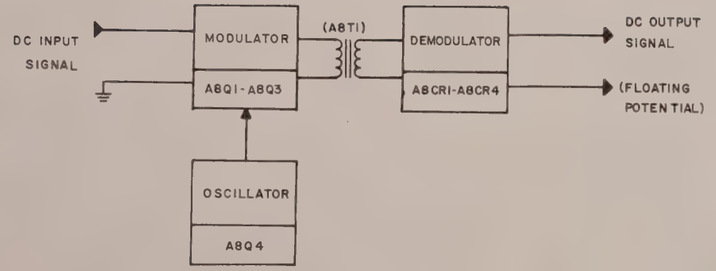


FIG. 4-10.
GRID SUPPLY

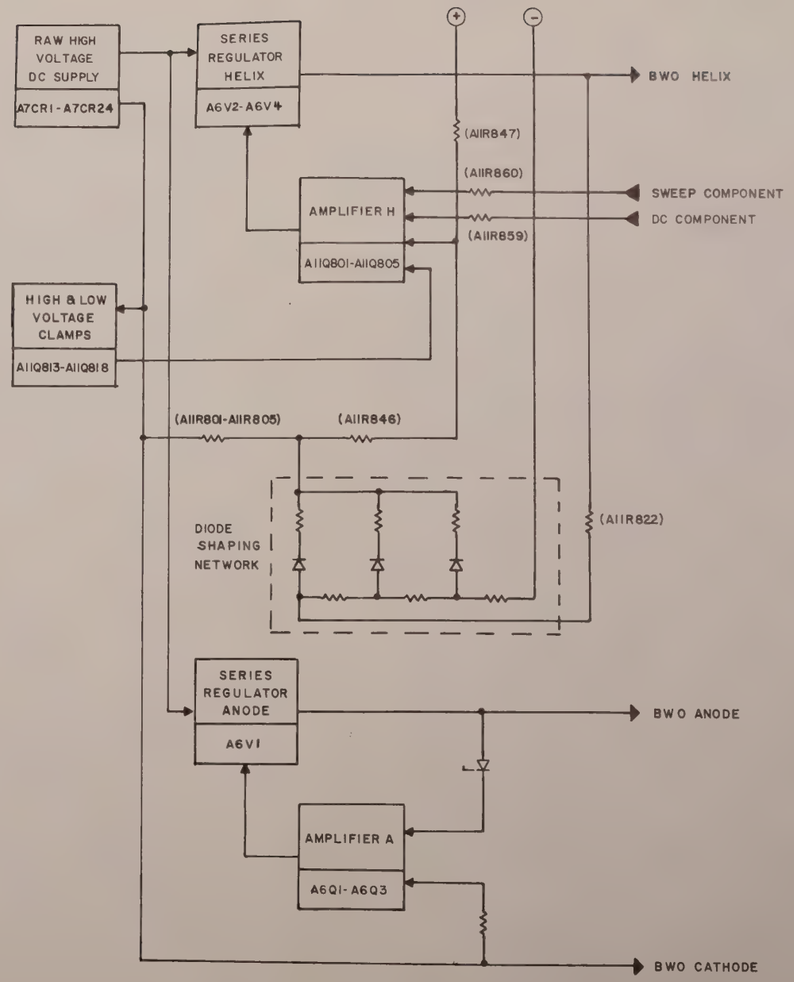
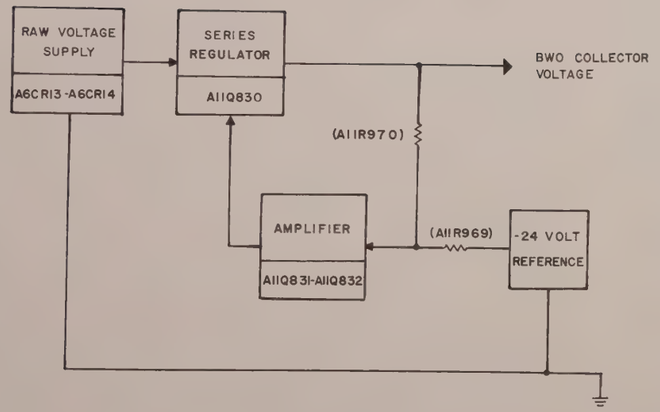
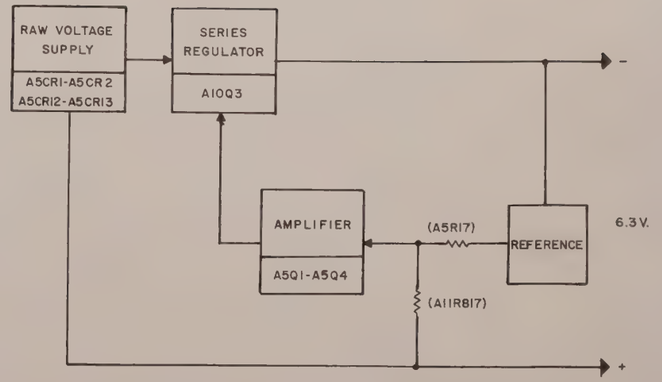


FIG. 4-11.
HELIX AND ANODE SUPPLIES

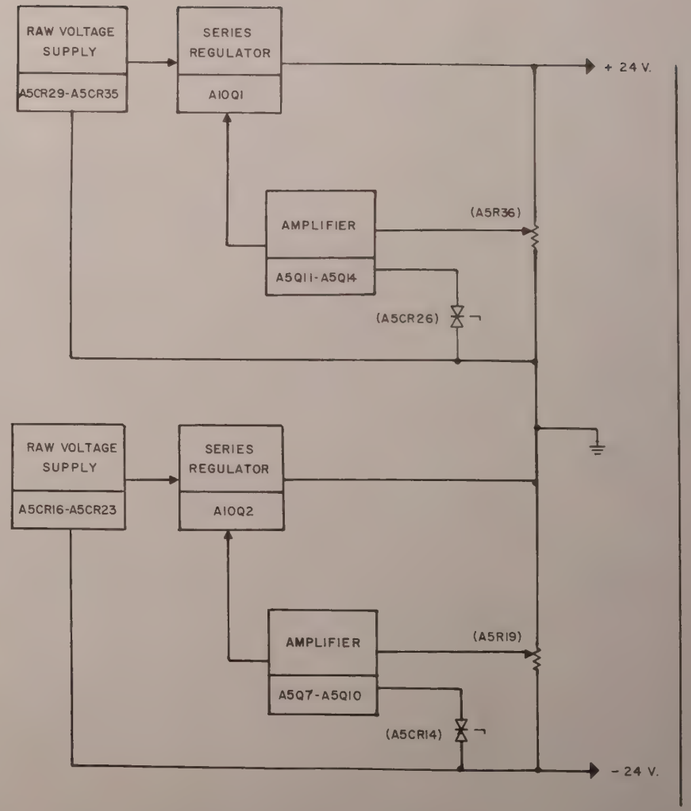
FIG. 4-10 & 4-11.
GRID SUPPLY
HELIX AND ANODE SUPPLIES
BLOCK DIAGRAMS
MODEL 221



COLLECTOR SUPPLY



FILAMENT SUPPLY



AUXILIARY SUPPLIES

FIG. 4-12.
COLLECTOR, FILAMENT & AUXILIARY SUPPLIES
BLOCK DIAGRAMS
MODEL 221

TABLE 5-0

TEST EQUIPMENT

Title	Manufacturer	Mfg. Part No.
Voltmeter Standard	Simpson	Model 1700
Miliampmeter Standard	Simpson	Model 1702
Variac	Superior Electric Co.	3PF116
A.C. Voltmeter	Weston	433
Oscilloscope with	Tektronix	516A
Differential Amplifier and	Tektronix	2A63
Time Base	Tektronix	2B67
Directional Couplers		
.200-.500 GHz	Anzac	DCG10
.5-1 GHz	Esca	70070-209
1-2 GHz	Narda	3042-10
2-4 GHz	Narda	3043-10
4-8 GHz	Narda	3044-10
8-12.4 GHz	Narda	3045C-10
12.4-18 GHz	Narda	1069-10
18-26 GHz	Narda	1068-10
26-40 GHz	HP	R752C
Crystal Detectors		
0.2-12.4 GHz	HP	423A
12.4-18 GHz	HP	P424A
18-26 GHz	HP	K422A
26-40 GHz	HP	R422A
10 dB Attenuators		
0.2-12.4 GHz	HP	8491A
12.4-18 GHz	HP	P375A
18-26 GHz	HP	K375A
26-40 GHz	HP	R375A
Frequency Meters		
0.2-0.5 GHz	Narda	804
0.5-1.0 GHz	Narda	805
1.0-4.0 GHz	HP	536A
4-8.2 GHz	General Microwave	N608A
8.2-12.4 GHz	HP	X532B
12.4-18 GHz	HP	P532A
18-26 GHz	HP	K532A
26-40 GHz	HP	R532A
Power Meter with Thermistor Mounts		
0.2-8.2 GHz	HP	478A
8.2-12.4 GHz	HP	X486A
12.4-18 GHz	HP	P486A
18-26 GHz	HP	K486A
26-40 GHz	HP	R486

SECTION 5-0.
MAINTENANCE

5-1. PERFORMANCE CHECK. The following checks are used to check the instrument against its specifications and are suggested as incoming out outgoing quality control checks.

5-2. POWER OUTPUT CHECK.

a. Connect a power meter to the RF OUTPUT through a pad. This pad should be selected to prevent application of excessive power to the power meter.

b. Set the controls of the sweeper as follows:

POWER----------RF ON
RF LEVELER--------OFF
SWEEP/CW----------M1
RF LEVEL----------MAX CW
M1----------LOW END OF BAND

c. Turn M1 control from low end of band to the high end of band and record minimum output power.

5-3. FREQUENCY CALIBRATION CHECK.

a. Connect the equipment as shown in Fig. 5-1.

b. Set the controls of the sweeper as follows:

POWER----------RF ON
RF LEVELER--------INT-XTAL
SWEEP/CW----------F1-F2
F1----------LOW LIMIT
F2----------HIGH LIMIT
SWEEP TIME (SEC)--0.1 SEC

c. Adjust the RF LEVEL control CCW just enough to obtain leveling across the entire band. If the plug-in Oscillator Unit does not have internal leveling components, set the RF LEVELER control in the OFF position and adjust the RF LEVEL control maximum CW.

d. Set the M1 and M2 indicators at the frequencies to be checked and tune the frequency meter to make the frequency meter dip coincident with each marker dip. The dial frequency reading and the frequency meter dial reading should agree within ±1%.

e. Check dial accuracy at various frequencies across the band.

5-4. SYMMETRICAL SWEEP WIDTH FREQUENCY CALIBRATION AND CHECK.

a. Connect the equipment as shown in Fig. 5-1.

b. Set the controls of the sweeper as follows:

POWER----------RF ON
RF LEVELER---------INT-XTAL
SWEEP/CW----------SYM
SYM CENTER FREQ----M1
M1----------CENTER OF BAND
SWEEP TIME (SEC)---0.1 SEC

c. Adjust the RF LEVEL control CCW just enough to obtain leveling across the entire band. If the plug-in Oscillator Unit does not have internal leveling components, set the RF LEVELER control in the OFF position and adjust the RF LEVEL control maximum CW.

d. For each setting of the SYMMETRICAL SWEEP WIDTH control set the frequency meter first at one end of the display and then at the other end of the display. Measure the difference in the frequency meter readings. This number should be within ±10% of the value set by the SYMMETRICAL SWEEP WIDTH control.

5-5. RESIDUAL FM CHECK.

a. Connect the equipment as shown in Fig. 5-1.

b. Set the controls of the sweeper as follows:

POWER----------RF ON
RF LEVELER---------OFF
RF LEVEL----------MAX CW
SWEEP/CW----------SYM
SYM CENTER FREQ----M1
M1----------CENTER OF BAND
SWEEP TIME (SEC)---0.01 SEC
SWEEP TRIGGERING---LINE
SYMMETRICAL SWEEP
WIDTH----------MAX CCW
RF DURING RETRACE--ON
(Rear Panel)

c. AC couple the vertical input of the oscilloscope and tune the frequency meter until the dip is centered on the display.

d. Referring to Fig. 5-2. place a straight edge on the face of the CRT and measure the slope of the resonance curve at its steepest point. Use the vertical calibration of the oscilloscope for the

amplitude measurement and the horizontal calibration of the SYMMETRICAL SWEEP WIDTH control of the sweeper for the frequency difference measurement. The slope of the frequency meter resonance should be recorded as a constant in millivolts/KHz. This section of the frequency meter response will now be used as a discriminator. Set the SWEEP/CW selector in the M1 position and adjust the time base of the oscilloscope for a conventional triggered scope display at a sweep of approximately 10 milliseconds per centimeter. Increase the vertical sensitivity of the oscilloscope and tune the frequency meter for maximum peak to peak amplitude on the display. Record the peak to peak amplitude. Divide the peak to peak amplitude by discriminator constant determined above to obtain the peak to peak residual FM. Divide the value of the peak to peak residual FM by 2 to obtain the peak residual FM.

5-6. INTERNAL AND EXTERNAL TRIGGER CHECK.

a. Connect the equipment as shown in Fig. 5-1. The frequency meter can be omitted.

b. Set the controls of the sweeper as follows:

POWER----------RF ON
SWEEP/CW----------F1-F2
SWEEP TIME (SEC)---1 SEC
SWEEP TRIGGERING---MAN
RF DURING RETRACE--OFF

c. Press MANUAL TRIGGER button and check the oscilloscope display to see that the sweep is triggered each time.

d. Set the SWEEP TRIGGERING control to the EXT position and connect a square wave generator to the EXT TRIG INPUT. Set the controls of the sweeper as follows:

SWEEP TIME---------0.01 SEC
SWEEP TRIGGERING---EXT

Set the square wave frequency to approximately 50Hz. Increase the amplitude output of the square wave generator until sweep is triggered. The amplitude should be -10 volts or less.

5-7. LEVELING CHECK.

5-8. INTERNAL LEVELING CHECK.

a. Connect a power meter to the RF OUTPUT through a pad. This pad should be selected to prevent application of excessive power to the power meter.

b. Set the controls of the sweeper as follows:

POWER----------RF ON
RF LEVELER--------INT XTAL
SWEEP/CW----------F1-F2
F1----------LOW END OF BAND
F2----------HIGH END OF BAND
SWEEP TIME (SEC)--10 SEC

c. Adjust the RF LEVEL control CCW just enough to obtain leveling across the entire band and the UNLEVELED indicator lamp goes off.

d. Observe the power meter indicator and note the maximum and minimum limit in dB. The value observed should be equal to or less than the total variation specified for the particular plug-in Oscillator Unit.

IMPORTANT: The observed variation includes the variation contributed by the pad located between the sweeper output and the power meter. Its variation therefore must be subtracted from the measured data to determine the variation caused by the sweeper.

5-9. EXTERNAL LEVELING CHECK.

a. Connect the equipment as shown in Fig. 5-3.

b. Set the controls of the sweeper as follows:

POWER----------RF ON
RF LEVELER--------EXT-XTAL
SWEEP/CW----------F1-F2
F1----------LOW END OF BAND
F2----------HIGH END OF BAND
SWEEP TIME (SEC)--0.01 SEC

c. Adjust the RF LEVEL control over its range. If the oscilloscope display shows oscillation in the leveling loop, vary the GAIN control to stop the oscillation. Then adjust the RF LEVEL control CCW just enough to obtain leveling across the entire band, causing the UNLEVELED indicator lamp to go off.

d. Connect the power meter as shown in Fig. 5-4 and set the SWEEP TIME control at 10 sec. Observe the power meter indicator and note the maximum and min-

imum limit in dB. The value observed should be equal to or less than the total variation specified for the particular plug-in Oscillator Unit. IMPORTANT: The observed variation includes the variation contributed by the pad located between the sweeper output and the power meter. Its variation therefore must be subtracted from the measured data to determine the variation caused by the sweeper.

5-10. POWER METER LEVELING CHECK.

a. Connect the equipment as shown in Fig. 5-3. except that a power meter is substituted for the crystal detector feeding the EXT DETECTOR INPUT. Use an HP431B power meter or equivalent. Connect the thermistor mount to the output of the directional coupler and the recorder output of the power meter to the EXT DETECTOR INPUT of the sweeper.

b. Set the controls of the sweeper as follows:

POWER----------RF ON
RF LEVELER--------POWER METER
SWEEP/CW----------F1-F2
F1----------LOW END OF BAND
F2----------HIGH END OF BAND
SWEEP TIME (SEC)--10 SEC
VARIABLE----------MAX CCW
GAIN (EXT
DETECTOR INPUT)---MAX CCW

c. Adjust the RF LEVEL control CCW just enough to obtain leveling across the entire band and the UNLEVELED indicator lamp goes off.

d. Observe the power meter indicator and note the power level variation on the power meter. Maximum variation should be less than ±0.1dB.

5-11. INTERNAL SQUARE WAVE MODULATION.

a. Connect the equipment as shown in Fig. 5-3.

b. Readjust EXT DETECTOR INPUT GAIN as described in Paragraph 5-9c.

c. Set the controls of the sweeper as follows:

POWER----------RF ON
RF LEVELER--------OFF
RF LEVEL----------MAX CW
SWEEP/CW----------M1
M1----------CENTER OF BAND
AMPLITUDE MOD-----⊓⊔

d. Rotate the ⊓⊔ 1000Hz control from CCW limit to CW limit. Frequency range should be 1000 ± 50Hz variation minimum. Symmetry 60/40% or better and rise time equal to or less than 1 microsecond.

e. Set the RF LEVELER control in the INT-XTAL or EXT-XTAL position as applicable and adjust the RF LEVEL control CCW just enough to obtain leveling and the UNLEVELED indicator lamp goes off.

f. Repeat step c. Frequency range should be 1000 ± 50Hz variation minimum, symmetry 60/40% or better and rise time approximately 10 microseconds.

5-12. EXTERNAL AM CHECK.

a. Connect the equipment as shown in Fig. 5-5.

b. Set the controls of the sweeper as follows:

POWER----------RF ON
RF LEVELER--------OFF
RF LEVEL----------MAX CCW
SWEEP/CW----------M1
M1----------CENTER OF BAND
AMPLITUDE MOD-----EXT

c. With the square wave generator set for 1000Hz, increase its output amplitude until further increase in input square wave amplitude does not increase the output RF amplitude. This input square wave amplitude should be equal to or less than 20 volts. Rise time equal to or less than 1 microsecond.

d. Set the RF LEVELER control in the INT-XTAL or EXT-XTAL position as applicable and repeat step c. Input square wave amplitude should be equal to or less than 20 volts and rise time approximately 10 microseconds.

5-13. CALIBRATION - BASIC UNIT.

5-14. TEST EQUIPMENT. Use a direct coupled oscilloscope for all oscilloscope measurements and a precision DC voltmeter (0.25% or better) for all voltmeter measurements.

5-15. PREPARATION OF EQUIPMENT. Prepare the Basic Unit as described in Section 5-24. of this manual. With a plug-in

f. MANUAL SWEEP ADJUSTMENT. The controls should be set as follows:

SWEEP TIME (SEC)----------MAN SWP
VARIABLE----------MAX CW
MARKER AMPLITUDE----------MAX CCW
M2----------MAX CCW
F1----------MAX CCW
F2----------MAX CW
SYMMETRICAL SWEEP VERNIER--MAX CCW
SWEEP OUTPUT AMPLITUDE-----MAX CW
SWEEP/CW----------F1-F2

Connect the voltmeter with (+) lead to A2TP1 and (-) lead to the chassis. Adjust A1R49 to read +20 volts ±50MV (see Fig. 5-7 for component and test point locations.

g. SIMULATING AMPLIFIER BALANCE. The controls should be set as follows:

SWEEP TIME (SEC)----------0.1 SEC
VARIABLE----------MAX CW
MARKER AMPLITUDE----------MAX CCW
M2----------MAX CCW
F1----------MAX CCW
F2----------MAX CCW
SYMMETRICAL SWEEP VERNIER--MAX CCW
SWEEP OUTPUT AMPLITUDE-----MAX CW
SWEEP/CW----------F1-F2

Connect the oscilloscope between A2TP2 and the chassis. Adjust A2R2 for zero volts ±3MV (see Fig. 5-7 for component and test point locations).

h. PRELIMINARY SIMULATING AMPLIFIER CALIBRATE. The controls should be set as follows:

SWEEP TIME (SEC)----------0.1 SEC
VARIABLE----------MAX CW
MARKER AMPLITUDE----------MAX CCW
M2----------MAX CCW
F1----------MAX CCW
F2----------MAX CW
SYMMETRICAL SWEEP VERNIER--MAX CCW
SWEEP OUTPUT AMPLITUDE-----MAX CW
SWEEP/CW----------F1-F2

Connect the oscilloscope between A2TP2 and the chassis. Adjust A2R19 for a negative peak of -10 volts ±50MV (see Fig. 5-7 for component and test point locations).

i. MARKER BALANCE. The controls should be set as follows:

SWEEP TIME (SEC)----------0.1 SEC
VARIABLE----------MAX CW
MARKER AMPLITUDE----------MAX CCW
M2----------MAX CCW
F1----------MAX CCW
F2----------MAX CCW
SYMMETRICAL SWEEP VERNIER--MAX CCW
SWEEP OUTPUT AMPLITUDE-----MAX CW
SWEEP/CW----------F1-F2

Connect the oscilloscope between A2TP3 and the chassis. Adjust A2R39 for zero volts ±5MV. Connect the oscilloscope between A2TP4 and the chassis. Adjust A2R64 for zero volts ±5MV (see Fig. 5-7 for component and test point locations).

j. FINAL SIMULATING AMPLIFIER CALIBRATE. The controls should be set as follows:

SWEEP TIME (SEC)----------0.1 SEC
VARIABLE----------MAX CW
MARKER AMPLITUDE----------MAX CCW
M2----------MAX CW
F1----------MAX CCW
F2----------MAX CW
SYMMETRICAL SWEEP VERNIER--MAX CCW
SWEEP OUTPUT AMPLITUDE-----MAX CW
SWEEP/CW----------F1-F2

Connect the vertical oscilloscope input to the INTERNAL MARKER OUTPUT jack at the rear of the Basic Unit and the horizontal oscilloscope input to the SWEEP OUTPUT jack. Adjust SWEEP OUTPUT AMPLITUDE control for the desired horizontal trace width on the oscilloscope. Turn MARKER AMPLITUDE control CW until markers appear on the trace. Readjust A2R19 (PRELIMINARY SIMULATING AMPLIFIER CALIBRATE) so that marker M2 appear coincident with the extreme right end of the oscilloscope display (see Fig. 5-7 for component and test point locations).

k. AMPLIFIER 2 POSITION AND AMPLITUDE ADJUSTMENT. The controls should be set as follows:

SWEEP TIME (SEC)----------0.1 SEC
VARIABLE----------MAX CW
MARKER AMPLITUDE----------Set per Para. 5-17j
M2----------MAX CW
F1----------MAX CW
F2----------MAX CCW
SYMMETRICAL SWEEP VERNIER--MAX CCW
SWEEP OUTPUT AMPLITUDE-----Set per Para. 5-17j
SWEEP/CW----------F1-F2

Connect the oscilloscope as described in paragraph 5-17j. Adjust A1R67 until marker M2 is coincident with extreme

left end of the oscilloscope display. Adjust A1R68 until marker M1 is coincident with extreme right end of the oscilloscope display (see Fig. 5-7 for component and test point locations).

1. SYMMETRICAL ZERO ADJUSTMENT.

The controls should be set as follows:

SWEEP TIME (SEC)----------0.1 SEC
VARIABLE----------MAX CW
MARKER AMPLITUDE----------Set per Para. 5-17j
M2----------MAX CW
F1----------MAX CCW
F2----------MAX CW
SYMMETRICAL SWEEP VERNIER--MAX CW
SWEEP OUTPUT AMPLITUDE-----Set per Para. 5-17j
SWEEP/CW----------SYM

Connect the oscilloscope as described in paragraph 5-17j. Adjust A1R77 so that the M1 marker is coincident with the center of the oscilloscope display (see Fig. 5-7 for component and test point locations).

m. DC FILAMENT ADJUSTMENT. The controls should be set as follows:

SWEEP TIME (SEC)----------0.1 SEC
VARIABLE----------MAX CW
MARKER AMPLITUDE----------Set per Para. 5-17j
M2----------MAX CCW
F1----------MAX CCW
F2----------MAX CCW
SYMMETRICAL SWEEP VERNIER--MAX CW
SWEEP OUTPUT AMPLITUDE-----Set per Para. 5-17j
SWEEP/CW----------SYM

Adjust A5R18 in accordance with instructions appearing in the Calibration procedure of the Oscillator Unit Instruction Manual (see Fig. 5-6 for component location).

n. ANODE CALIBRATION. The controls should be set as follows:

SWEEP TIME (SEC)----------0.1 SEC
VARIABLE----------MAX CW
MARKER AMPLITUDE----------Set per Para. 5-17j
M2----------MAX CCW
F1----------MAX CCW
F2----------MAX CCW
SYMMETRICAL SWEEP VERNIER--MAX CW
SWEEP OUTPUT AMPLITUDE-----Set per Para. 5-17j
SWEEP/CW----------SYM

Turn unit's POWER switch to OFF position. Turn A11R819 (ANODE ADJUST) to its MAX CCW position (this component is in the Oscillator Unit, for access see Section 5-23 of this manual). Connect the voltmeter (+) lead to A11TPD (BWO ANODE) and (-) lead to A11TPC (BWO CATHODE). Check the value of A11R818 in the Oscillator Unit. This value, when substituted in the following formula, will yield a correct value for the anode voltage:

Resistance x 10^{-3} = Anode Voltage

For Example:

A11R818 = 100 K ohms

Anode Voltage = 100K x 10^{-3} = 100 Volts

CAUTION: BOTH THE VOLTMETER AND ADJUSTMENT POTENTIOMETER ARE AT KILOVOLT POTENTIAL. Turn POWER switch to RF ON position. After RF ON indicator lights, adjust, with an INSULATED SCREWDRIVER, A6R12 to read the value of voltage found from above formula (see Fig. 5-8 and specific Oscillator Unit Instruction Manual for component and test point locations).

Turn unit's POWER switch to RF OFF position.

5-18. CALIBRATION OF THE OSCILLATOR UNIT. The calibration procedures for the Oscillator Unit appear in the specific Oscillator Unit Instruction Manual.

5-19. PERIODIC MAINTENANCE.

5-20. CLEANING AIR FILTER. The fan filter should be cleaned periodically to insure proper cooling. The fan may be serviced by following the steps listed below:

a. Remove the filter by prying under the outer edges of the grille frame with a screwdriver in the indicated openings until the grille frame is removed.

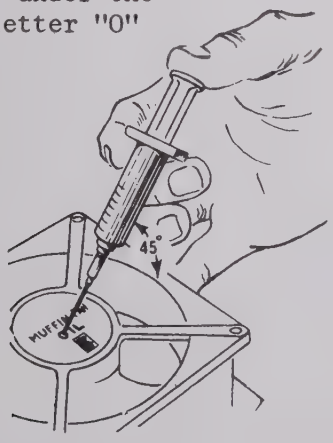
b. Remove the filter and immerse in any chemical solvent which will remove the accumulated dirt.

c. When the filter is clean and dry it should be sprayed with a light coat of oil and then reinserted.

5-21. OILING THE FAN MOTOR. For best, long life performance, oil the fan at least once a year. In installations of unusually severe service or environment, oil more frequently. To inject oil into the bearing:

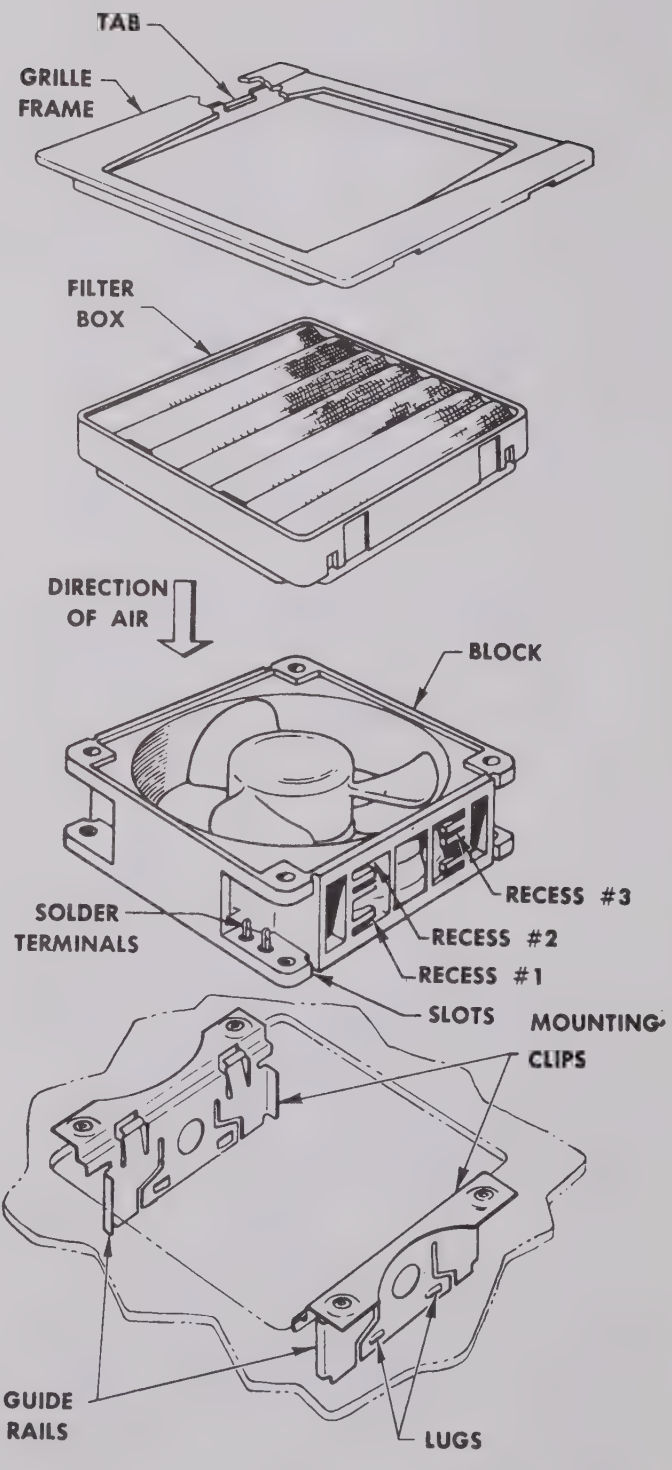
a. Position the needle at an angle of 45° to the seal on the label.

b. Pierce label and concealed self-sealing rubber cap under the label in letter "O" in oil.



c. Depress plunger firmly until oil has gone down one calibration line.

d. Withdraw the needle and wipe off excess oil. Oil may be left in the syringe for future use.



5-22. REMOVABLE ASSEMBLIES. The Microwave Sweep Oscillator consists of a Basic Unit and plug-in Oscillator Units. The plug-in Oscillator Unit is located in the lower right hand portion of the Basic Unit. The panel in the lower left hand portion is not a plug-in unit, however, it is designed to be removed as a subassembly and is referred to as the Waveform Generator.

5-23. PLUG-IN OSCILLATOR UNIT. To service the plug-in Oscillator Unit proceed as follows:

a. Remove the plug-in Oscillator Unit.

b. Remove the handle on the left side of the unit.

c. Rest the Basic Unit on its left side.

d. Remove the Basic Unit bottom plate.

e. Remove the guide rail in the Basic Unit used to guide the plug-in Oscillator Unit.

f. Remove the bottom cover of the plug-in Oscillator Unit.

g. Carefully insert the plug-in Oscillator Unit, guiding the back end of the plug-in to engage the multiple contact connector.

h. The unit can now be operated in its normal modes. If further accessibility to the Oscillator Unit's circuit board is required, the board can swing out by removing the screws holding the board to the frame.

i. If it is desired to operate the plug-in completely removed from the basic unit, a jumper cable approximately 3 ft long with mating connectors at each end can be used.

CAUTION: When this jumper cable is used a separate ground connection must be made between the Oscillator Unit plug-in chassis and the Basic Unit chassis. A clip to clip lead can be used.

5-24. WAVEFORM GENERATOR. To service the Waveform Generator proceed as follows:

a. Remove the handle on the left side of the unit.

b. Rest the Basic Unit on its left side.

c. Remove the bottom plate.

d. Remove two nuts located behind the Waveform Generator panel at the lower left and lower right corners.

e. Disengage the multiple contact connector located on the left side panel of the Basic Unit.

f. Withdraw the Waveform Generator assembly taking care that none of the circuit components strike the edge of the front panel opening.

g. The multiple contact connector can now be engaged and the Waveform Generator can be operated in its normal modes. If further accessibility is required, the printed circuit boards can swing out by removing the screws holding the boards to the frame.

5-25. IDENTIFICATION OF SUBASSEMBLIES AND COMPONENTS. To make all subassemblies accessible proceed as follows:

a. Remove the handle on the left side of the Basic Unit.

b. Rest the Basic Unit on its left side.

c. Remove the top and bottom plates. Referring to Fig. 5-8, the various subassemblies and components can now be identified.

d. Referring to the Component Layouts of Figures 5-9 thru 5-14 individual components, which are located within specific subassemblies, can be identified.

e. All subassemblies and components are identified by Reference Designations. A complete explanation of both the meaning and use of these Reference Designations can be found in Sections 6-1 and 6-2 of this manual.

5-26. TROUBLE SHOOTING PROCEDURE.

5-27. GENERAL. When a unit is found to be operating improperly check the trouble symptoms against those listed in Tables 5-1 to 5-5.

5-28. BWO MALFUNCTION. When the BWO is indicated as the source of the trouble proceed as follows to isolate the trouble

to the BWO or the equipment power supplies.

a. Prepare the instrument for servicing as described in paragraph 5-24.

b. Remove all BWO leads from the screw terminals.

c. Set the controls of the sweeper as follows:

POWER----------RF OFF
RF LEVELER----------OFF
RF LEVEL----------MAX CW
SWEEP/CW----------M1
M1----------CENTER OF BAND

d. Measure the following electrode voltages:

FILAMENT----------6.3 VOLTS
GRID TO CATHODE-----0 to -1 VOLT
COLLECTOR TO HELIX--+45 VOLTS

e. Place the power control in the RF ON position.

CAUTION: Dangerously high voltages are present between the BWO leads and the instrument.

Measure the following electrode voltages:

ANODE TO CATHODE--approx.+ 100 VOLTS
HELIX TO CATHODE--approx.+1000 VOLTS

f. Turn the RF power off and reconnect the BWO with a milliammeter in series with the CATHODE lead and one in series with the HELIX lead. Turn the RF power on and measure the CATHODE and HELIX currents and compare these values with those given for the BWO in the Oscillator Unit Instruction Manual.

5-29. SCHEMATIC AND BLOCK DIAGRAMS. The schematic and block diagrams for the Model 221 Sweep Oscillator are listed in Section 5 and Section 4, respectively, of the lists of illustrations. Table 5-6 provides an explanation of the graphic symbols employed in these diagrams.

TABLE 5-1 (CON'T)

TABLE OF GENERAL TROUBLE SYMPTOMS

Symptom	Trouble Location	Cause
	Filament trip circuit	Defective component
Unit trips off in CW mode at particular frequency setting	BWO	Excessive helix current
Time delay does not fire and unit does not cycle on	Time delay relay	Defective component
	K1 relay	Bad contacts
No sweep	±24 volt supply	Blown fuse Defective component
	Sweep Generator	Defective component
Sweep sluggish and cannot sweep at fast rates	Helix supply	Bandwidth control jumpers improperly connected; see paragraph 3-20
Frequency calibration off	Basic Unit	Requires recalibration
	Marker circuit	Defective component
	±24 volt supply	Incorrect output voltage - defective component
	Helix supply	Defective component
No square wave modulation	Square wave oscillator	Defective component
High residual FM in CW mode	BWO	Defective
	Helix supply	Excessive ripple Bandwidth jumpers are improperly connected; see paragraph 3-20
	Improper settings of controls	See paragraph 3-20

TABLE 5-2

TROUBLE SHOOTING THE FILAMENT SUPPLY

Step	Symptom	Procedure	Indication	Conclusion
1	High Output	Remove A5Q1	Output drops	Proceed to step 2
			No change	Defective A10Q3 or associated circuitry
2		Remove A5Q2	Output drops	Proceed to step 3
			No change	Defective A5Q1 or associated circuitry
3		Remove A5Q3	Output drops	Proceed to step 4
			No change	Defective A5Q2 or associated circuitry
4		Remove A5Q4, place 1K Resistor between collector and emitter points	Output drops	Defective A5Q4 or associated circuitry including A11R817
			No change	Defective A5Q3 or associated circuitry
5	Low or zero output	Remove A5Q1, place 1K Resistor between collector and emitter points	Output increases	Proceed to step 6
			No change	Defective A10Q3 or associated circuitry
6		Remove A5Q2, place 1K Resistor between collector and emitter points	Output increases	Proceed to step 7
			No change	Defective A5Q1 or associated circuitry
7		Remove A5Q3, place 1K Resistor between collector and emitter points	Output increases	Proceed to step 8
			No change	Defective A5Q2 or associated circuitry
8		Remove A5Q4	No change	Defective A5Q3 or associated circuitry
			Output increases	Defective A5Q4, A5CR5 or associated circuitry

TABLE 5-3

TROUBLE SHOOTING THE ±24V SUPPLIES

NOTE: The -24 volt supply is identical to the +24 volt supply. The schematic references are indicated for the +24 volt supply. The -24 volt supply schematic references are shown in parentheses.

Step	Symptom	Procedure	Indication	Conclusion
1	High Output	Remove A5Q14 (A5Q10)	Output drops	Proceed to step 2
			No change	Defective A10Q1 (A10Q2) or associated circuitry
2		Remove A5Q12 (A5Q8)	Output drops	Proceed to step 3
			No change	Defective A5Q13 (A5Q9) or associated circuitry
3		Remove A5Q11 (A5Q7) Place 1K Resistor between collector and emitter points of section "A"	Output drops	Defective A5Q11 (A5Q7) or associated circuitry
			No change	Defective A5Q12 (A5Q8) or associated circuitry
4	Low or zero output	Check fuse	If blown	Replace
5		Check A.C. and raw D.C. voltages	If O.K.	Proceed to step 6
6		Remove A5Q14 (A5Q10) Place 1K Resistor between collector and emitter points	Output increases	Proceed to step 7
			No change	Defective A10Q1 (A10Q2) or associated circuitry
7		Remove A5Q13 (A5Q9)	Output increases	Proceed to step 8
			No change	Defective A5Q14 (A5Q10) or associated circuitry
8		Remove A5Q12 (A5Q8) Place 1K Resistor between collector and emitter points	Output increases	Proceed to step 9
			No change	Defective A5Q13 (A5Q9) or associated circuitry
9		Remove A5Q11 (A5Q7)	Output increases	Defective A5Q11 (A5Q7) or associated circuitry
			No change	Defective A5Q12 (A5Q8) or associated circuitry

TABLE 5-4

TROUBLE SHOOTING THE HELIX SUPPLY

NOTE: All measurements should be taken with the power control switch in the RF ON position and the SWEEP/CW switch in the M1 position.

CAUTION: The helix supply output is at kilovolt potential.

Step	Symptom	Procedure	Indication	Conclusion
1	Output too high. No RF from BWO	Check -36V on Junction of A11R861 and A11R862	-36V present	Proceed to step 2
			-36V missing	Defective A5CR24 or associated circuitry
2		Remove A11Q801	Helix voltage drops	Proceed to step 3
			No change	Circuit of A11R862, A6V1-A6V3. Grids open A6V1-A6V3
3		Remove A11Q802	Helix voltage drops	Proceed to step 4
			No change	Defective A11Q801 or associated circuitry
4		Remove A11Q804	Helix voltage drops	Proceed to step 5
			No change	Defect in circuit of A11Q802-Q803
5		Remove A11Q805B transistor leads	Helix voltage drops	Defective A11Q805 or associated circuitry including clamp circuits
			No change	Defect in A11Q804 circuit
6	Low or zero output	Check high voltage on plates of A6V2-A6V4	Present	Proceed to step 7
			Missing	Defect in circuit of A10T1 or in H.V. Rectifier Bridge
7		Remove A11Q801, Place 1K resistor between collector and emitter points	Output increases	Proceed to step 8
			No change	Defective A11R851, A11R862 or associated circuitry

TABLE 5-5

TROUBLE SHOOTING THE ANODE SUPPLY

NOTES: 1. All measurements should be taken with the power control switch in the RF ON position and the SWEEP/CW switch in the M1 position.
2. When "High Output" or "Increasing Output" is given as a symptom or indication in the step-by-step trouble shooting instructions, it usually means that the unit will trip off. In this case the unit has to be turned off and on again before proceeding to the next step.

CAUTION: The anode of the BWO is several kilo volts negative with respect to the chassis of the instrument.

Step	Symptom	Procedure	Indication	Conclusion
1	Output very low or zero volts on terminals "C" and "D" of oscillator board	Check 2,100 volts between terminal "A" on oscillator board and plate cap of tube A6V1	Normal	Proceed to step 2
			Very low or zero	Possible defect in A7R1-A7R3, A7CR1-A7CR19, A10T1 or associated circuitry
2		Measure D.C. voltage between cathode and grid of A6V1	Grid voltage more than -12V	Proceed to step 3
			Grid voltage less than -12V	Open circuit from A6V1 cathode to terminal "D" on oscillator board or defective A6V1
3		Remove A6Q1. Place 5K resistor between collector and emitter points	Output increases	Proceed to step 4
			No change	Possible defect in A6V4, A6CR7, A6R6, A6R14 or associated circuitry
4		Remove A6Q2. Place 1K resistor between collector and emitter points	Output increases	Proceed to step 5
			No change	Defective A6Q1 or associated parts
5		Remove A6Q3	Output increases	Defective A6Q3 or associated parts
			No change	Possible defect in A6Q2, A6R3, A6R12, A6R10, A6CR6, A6R2 or associated circuitry
6	High output	Remove A6Q1	Output drops	Proceed to step 7

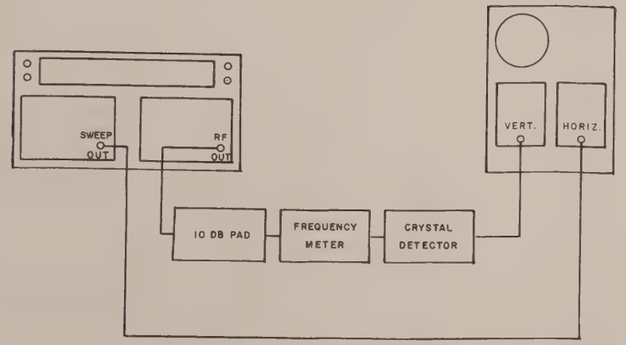


FIG. 5-1.
FREQUENCY MEASUREMENT

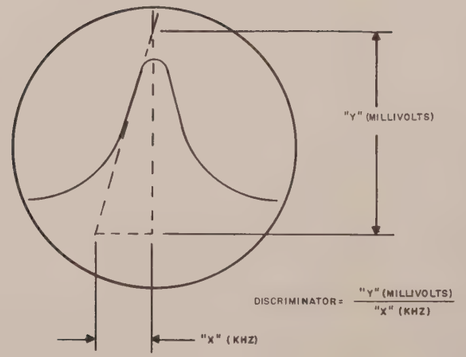


FIG. 5-2.
FREQUENCY DISCRIMINATOR

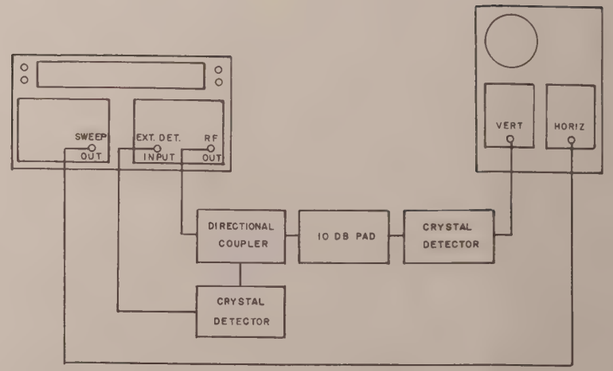


FIG. 5-3.
EXTERNAL LEVELING

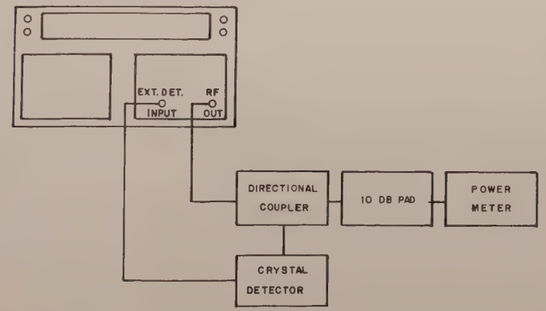


FIG. 5-4.
POWER LEVEL CHECK

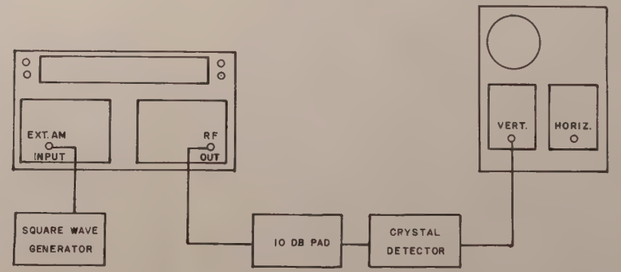


FIG. 5-5.
SQUARE WAVE MODULATION

FIG. 5-1. TO 5-5.
SETUPS FOR PERFORMANCE CHECKS
MODEL 221

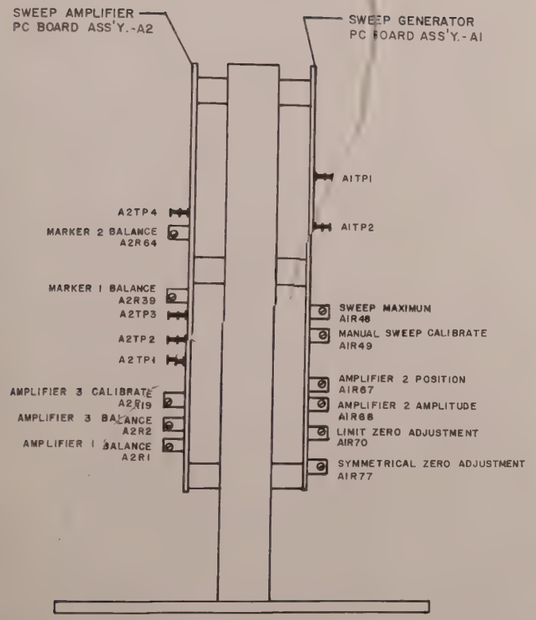


FIG. 5-7.
WAVEFORM GENERATOR CALIBRATION
COMPONENT AND TEST POINT LOCATION

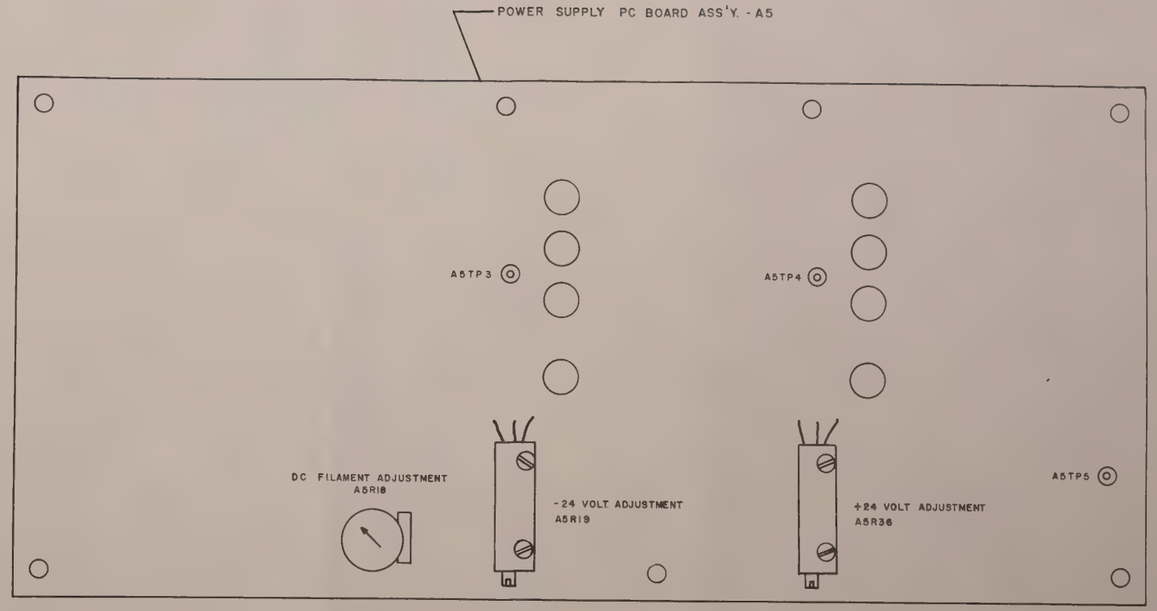


FIG. 5-6.
± 24 VDC AND DC FILAMENT SUPPLY CALIBRATION
COMPONENT AND TEST POINT LOCATION

FIG. 5-6. & 5-7.
CALIBRATION DIAGRAMS
MODEL 221

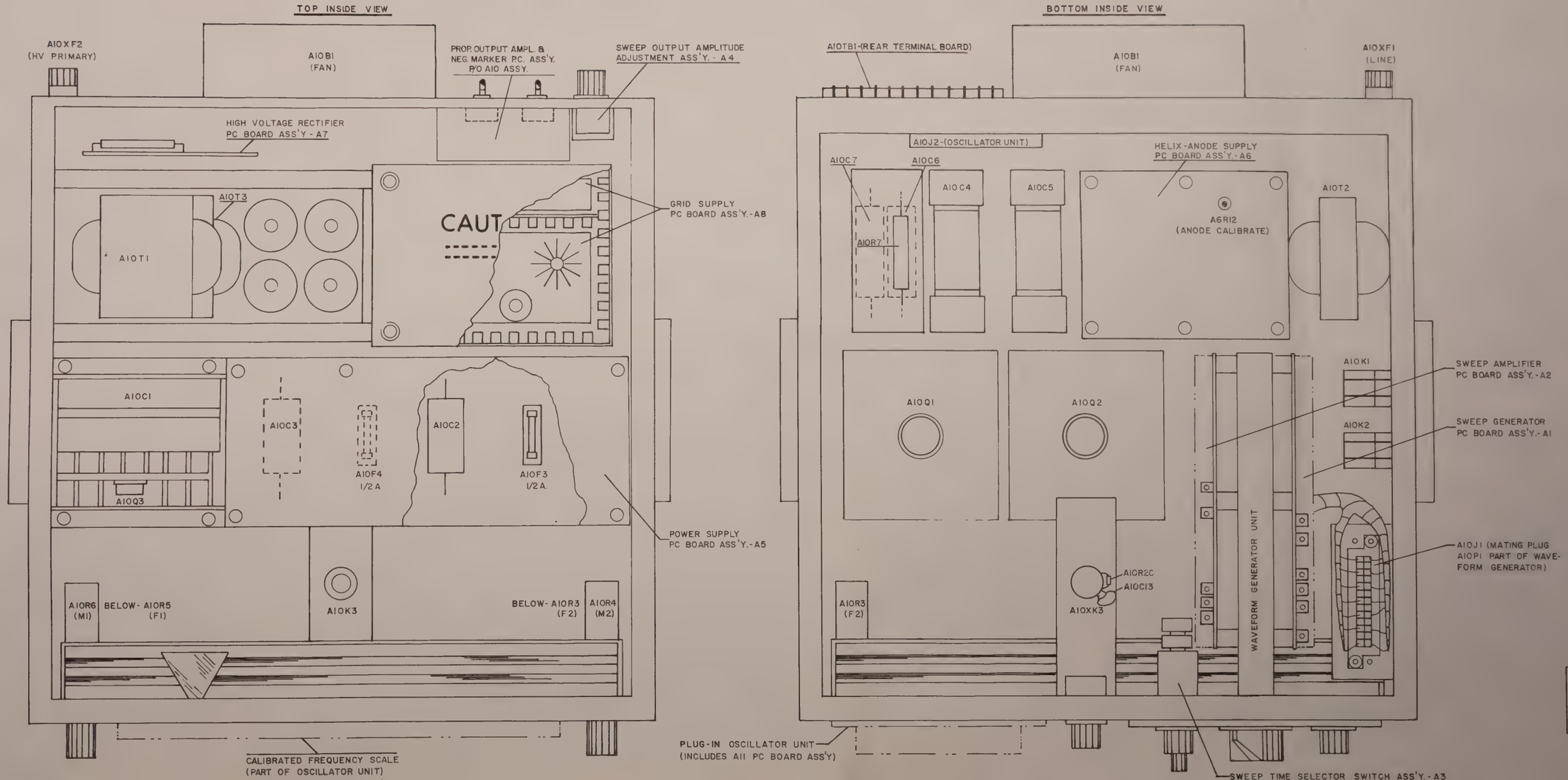


FIG. 5-8
IDENTIFICATION OF SUBASSEMBLIES AND COMPONENTS
MODEL 221

A1 ASSEMBLY

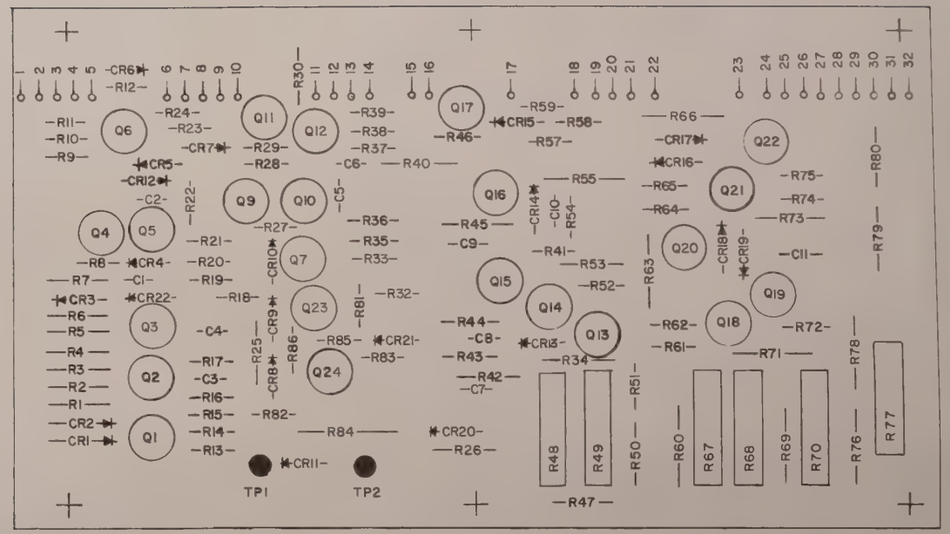


FIG. 5-9
SWEEP GENERATOR
P.C. BOARD LAYOUT
MODEL 221

A2 ASSEMBLY

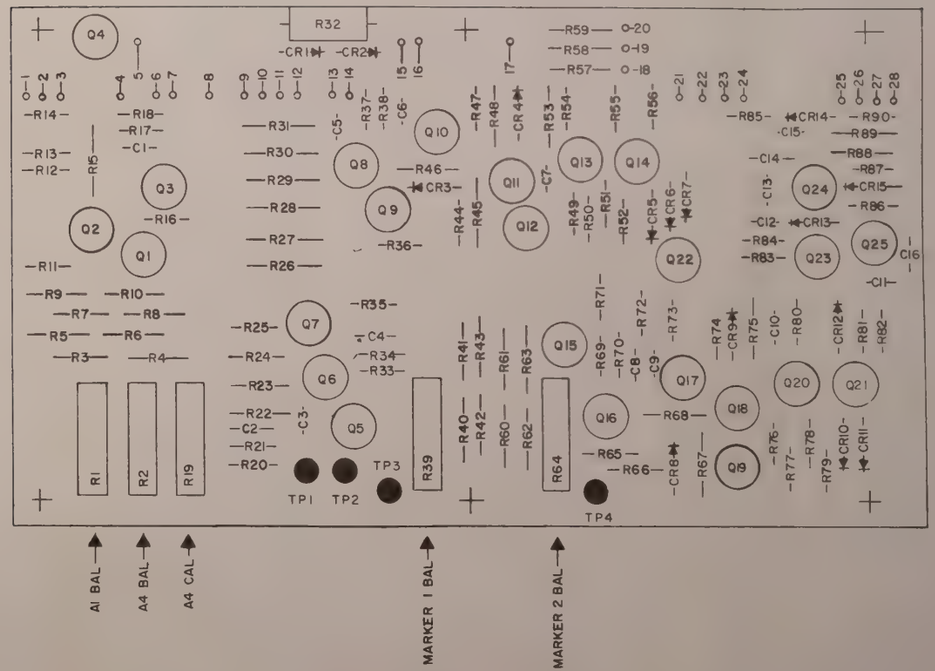


FIG. 5-10
SWEEP AMPLIFIER
P.C. BOARD LAYOUT
MODEL 221

A5 ASSEMBLY

FIG. 5-11
POWER SUPPLY
P.C. BOARD LAYOUT
MODEL 221

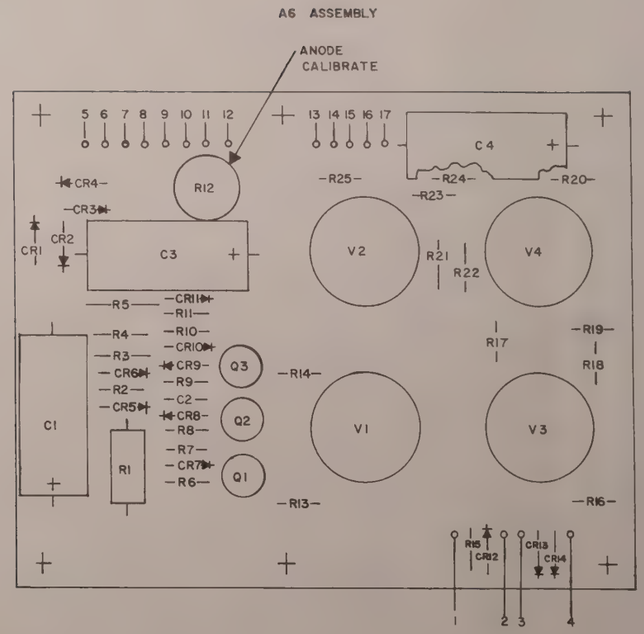


FIG. 5-12
HELIX-ANODE SUPPLY
P.C. BOARD LAYOUT
MODEL 221

A7 ASSEMBLY

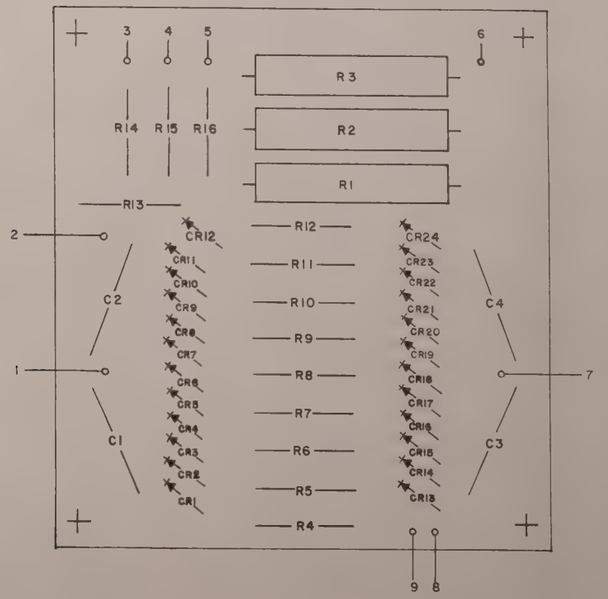


FIG. 5-13
H.V. RECTIFIER
P.C. BOARD LAYOUT
MODEL 221

A8 ASSEMBLY

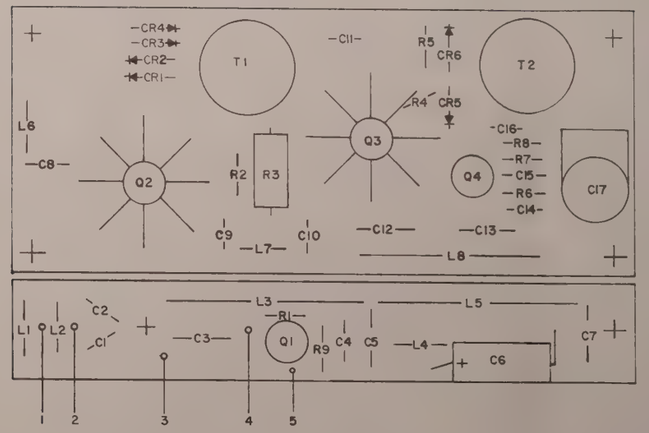


FIG. 5-14
GRID SUPPLY
P.C. BOARD LAYOUT
MODEL 221

P/O A10 ASSEMBLY

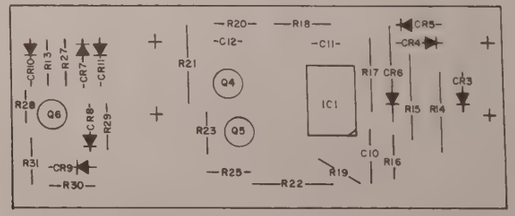


FIG. 5-15
PROPORTIONAL OUTPUT AMPLIFIER
NEGATIVE VIDEO MARKER
P.C. BOARD LAYOUT
MODEL 221

TABLE 5-6.

(FOR SYMBOLS NOT SHOWN IN THIS TABLE REFER TO MIL-STD-15)

SEMICONDUCTORS & VACUUM TUBES

DIODE, SEMICONDUCTOR

BREAKDOWN DIODE, UNIDIRECTIONAL

BREAKDOWN DIODE, BIDIRECTIONAL

TRANSISTOR, NPN TYPE

TRANSISTOR, PNP TYPE

DIFFERENTIAL AMPLIFIER

VACUUM TUBE, TETRODE

SWITCHES

DECK-POLE

SWITCH, MULTIPOSITION NON-SHORTING

SWITCH, MOMENTARY PUSH BUTTON, NORMALLY OPEN

INPUTS, OUTPUTS & TERMINATIONS

INPUT FROM ANOTHER INTERNAL SYSTEM

OUTPUT TO ANOTHER INTERNAL SYSTEM

INPUT CONNECTOR

OUTPUT CONNECTOR

INPUT TERMINAL-LOCATED ON REAR PANEL

OUTPUT TERMINAL-LOCATED ON REAR PANEL

POSITIVE INTERNAL SUPPLY

NEGATIVE INTERNAL SUPPLY

SYSTEM GROUND

CONTROLS & ADJUSTMENTS

KNOB ADJUSTMENT OR CONTROL

SCREWDRIVER ADJUSTMENT

INDICATOR LAMP-LOCATED ON FRONT PANEL

ADJUSTMENT OR CONTROL-LOCATED ON FRONT PANEL

ADJUSTMENT OR CONTROL-LOCATED ON REAR PANEL

NOTE: UNLESS OTHERWISE SPECIFIED ALL CAPACITANCES ARE IN MICROFARADS, INDUCTANCES IN MICROHENRIES, AND RESISTANCES IN OHMS.

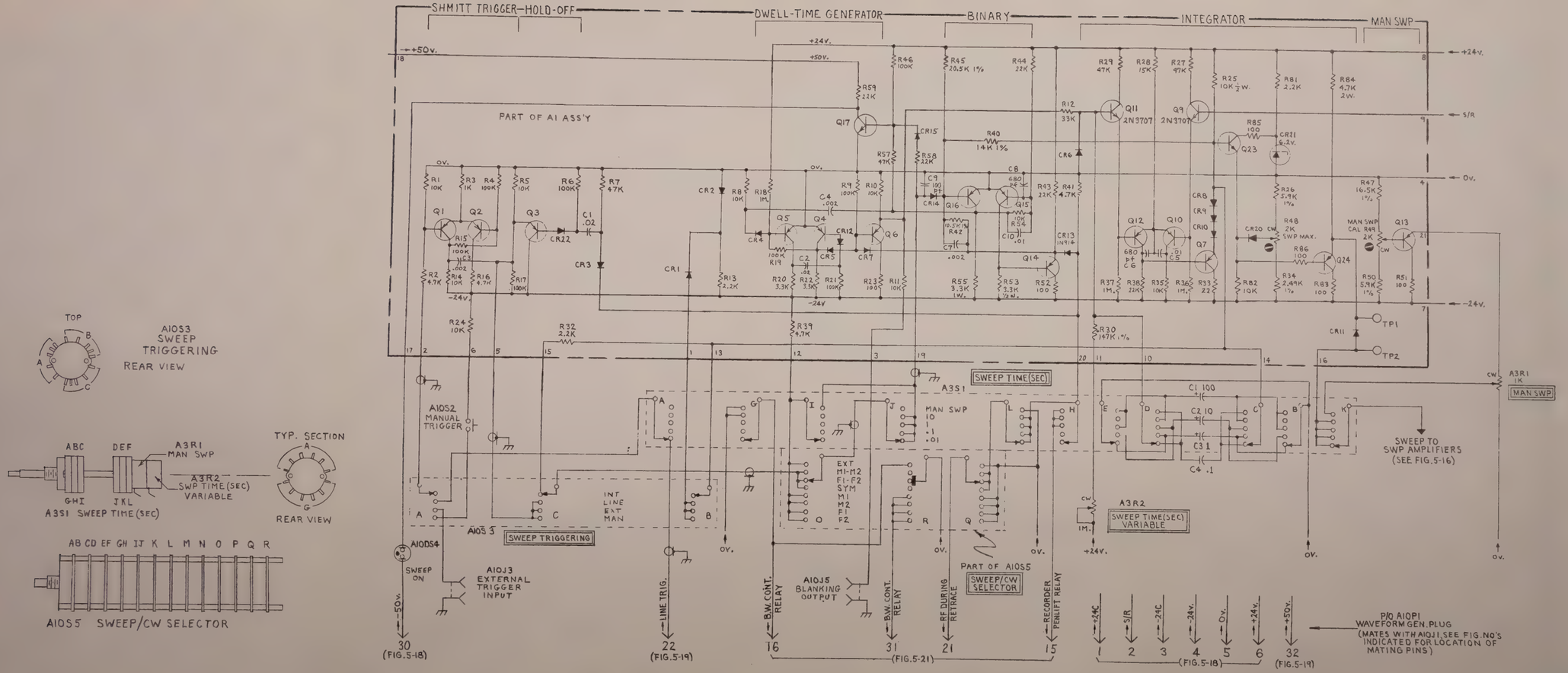
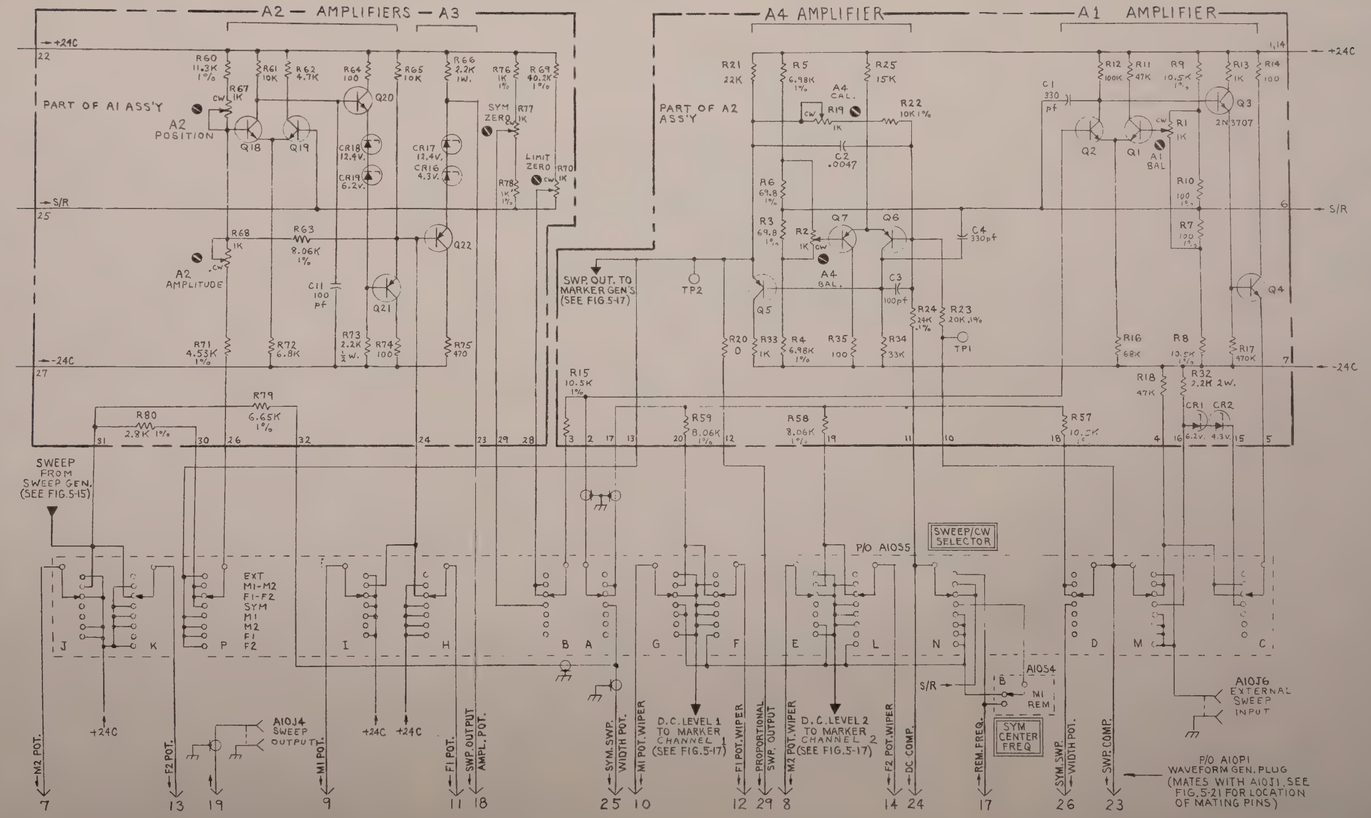


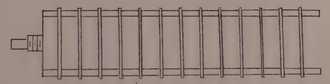
FIG. 5-16
SWEEP GENERATOR
SCHEMATIC
MODEL 221

ECN 285 NEXT ECN



A1A4
SYMMETRICAL
CENTER FREQ.

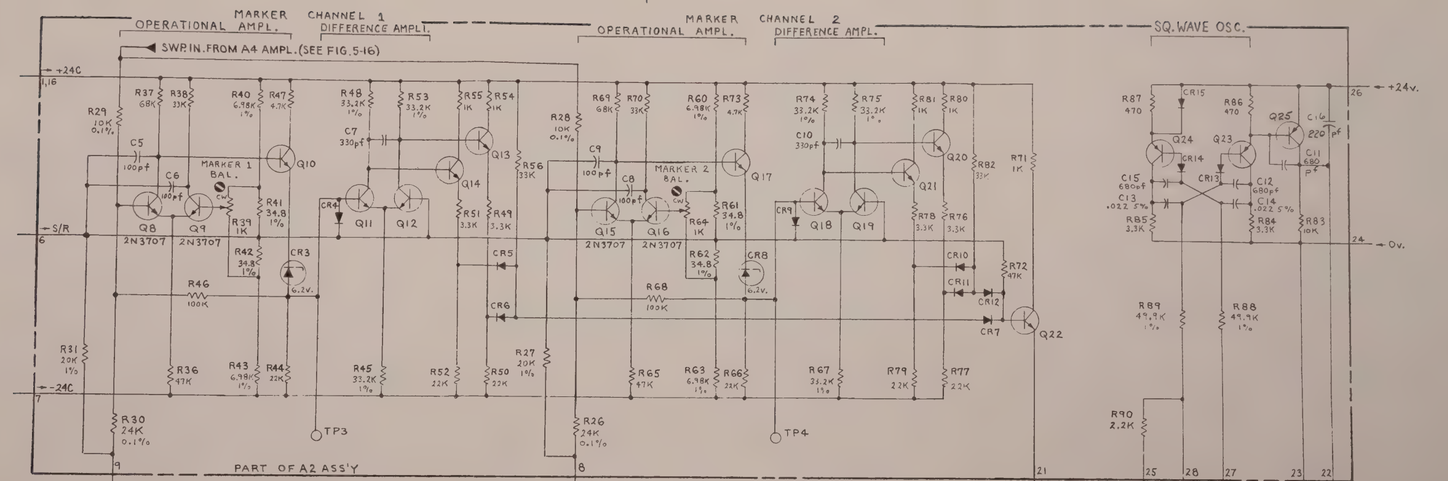
REAR VIEW



A1A5 SWEEP/CW SELECTOR

FIG. 5-17
SWEEP AMPLIFIERS
SCHEMATIC
MODEL 221

ECN 330



A10S6
AMPLITUDE MOD.
REAR VIEW

FIG 5-18
MARKER/SQ. WAVE GEN'S
SCHEMATIC
MODEL 221

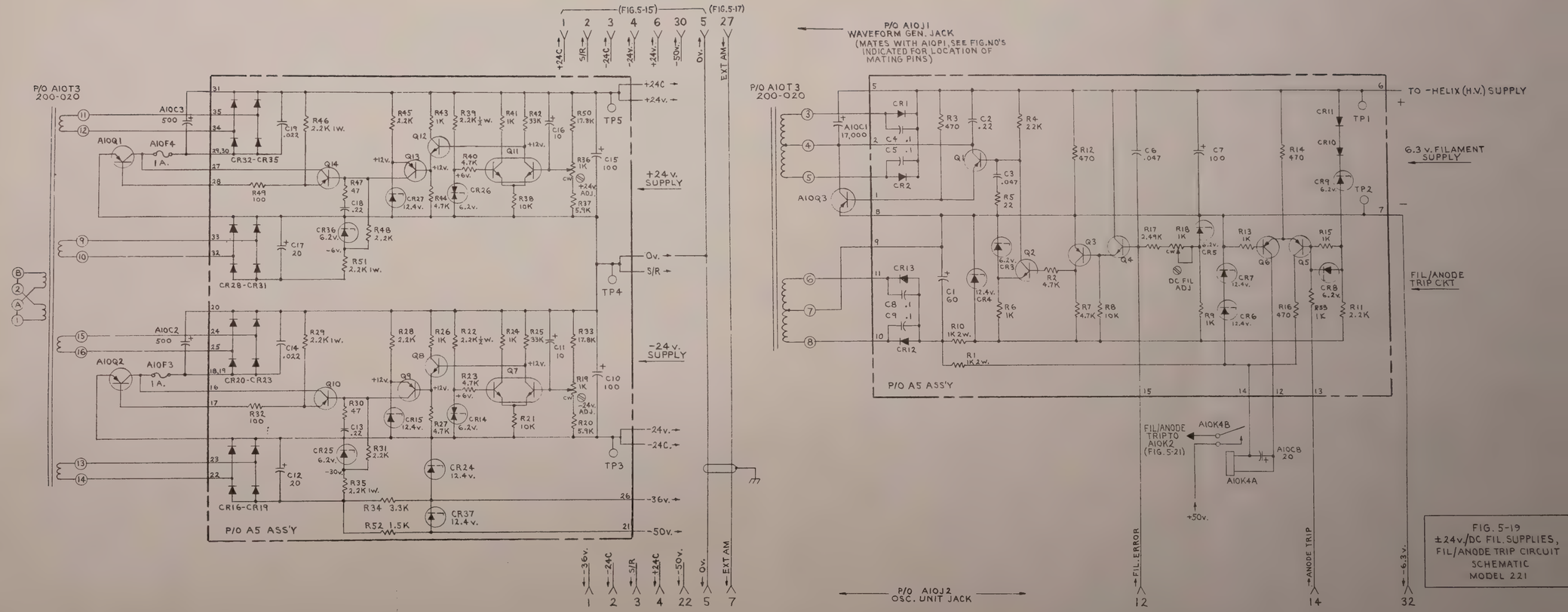


FIG. 5-19
±24v./DC FIL. SUPPLIES, FIL/ANODE TRIP CIRCUIT SCHEMATIC MODEL 221

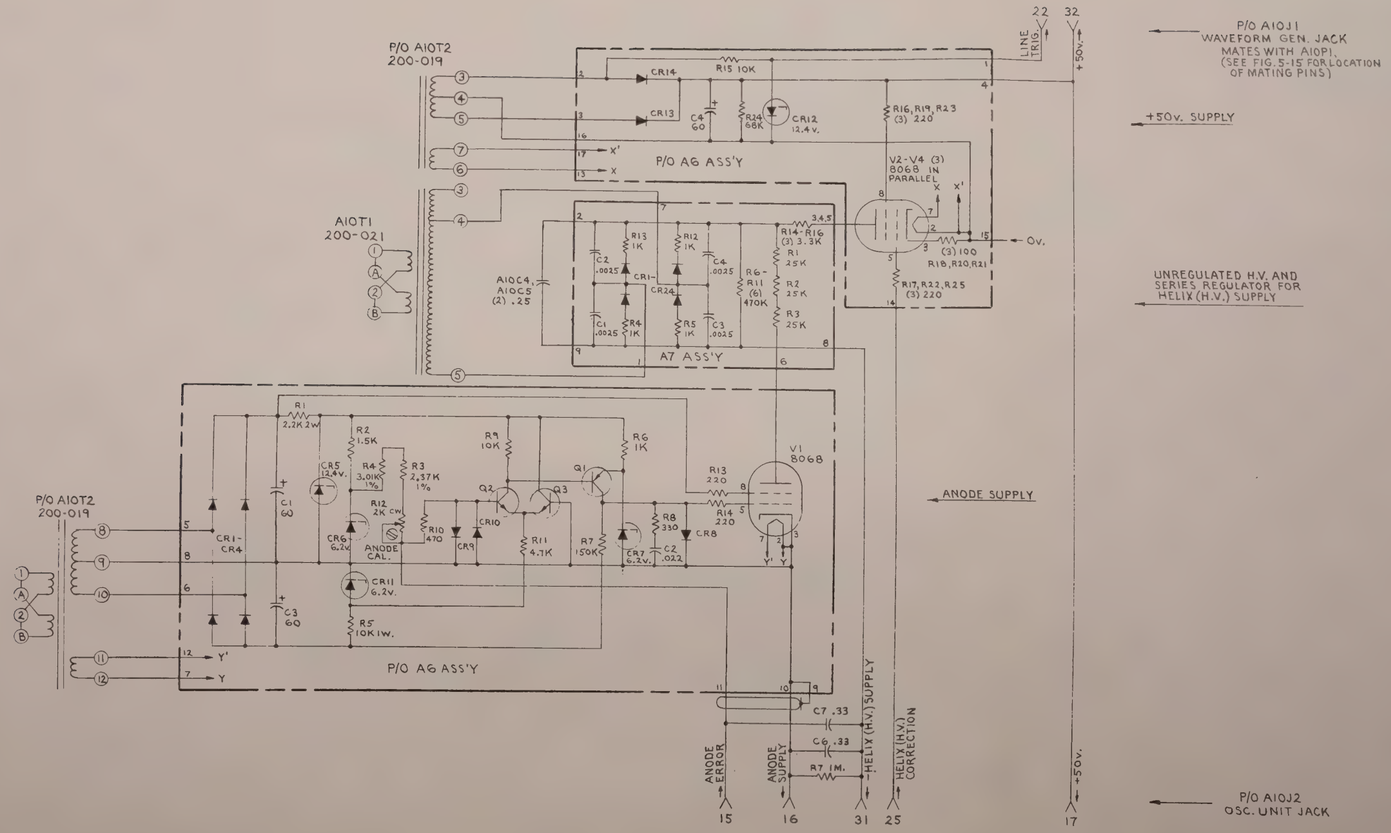


FIG. 5-20
HELIX/ANODE SUPPLIES
SCHEMATIC
MODEL 221

ECN 335

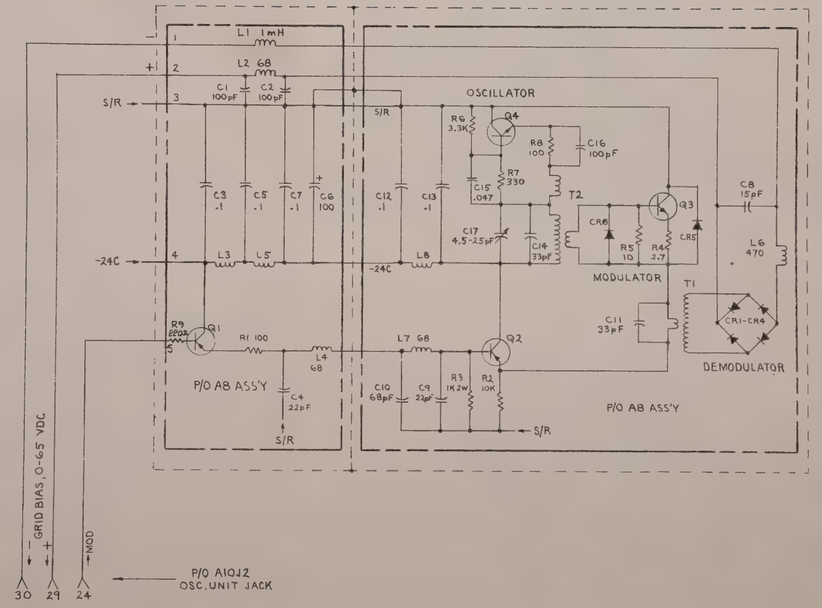


FIG. 5-21
GRID SUPPLY
SCHEMATIC
MODEL 221

ECN 382 NEXT ECN

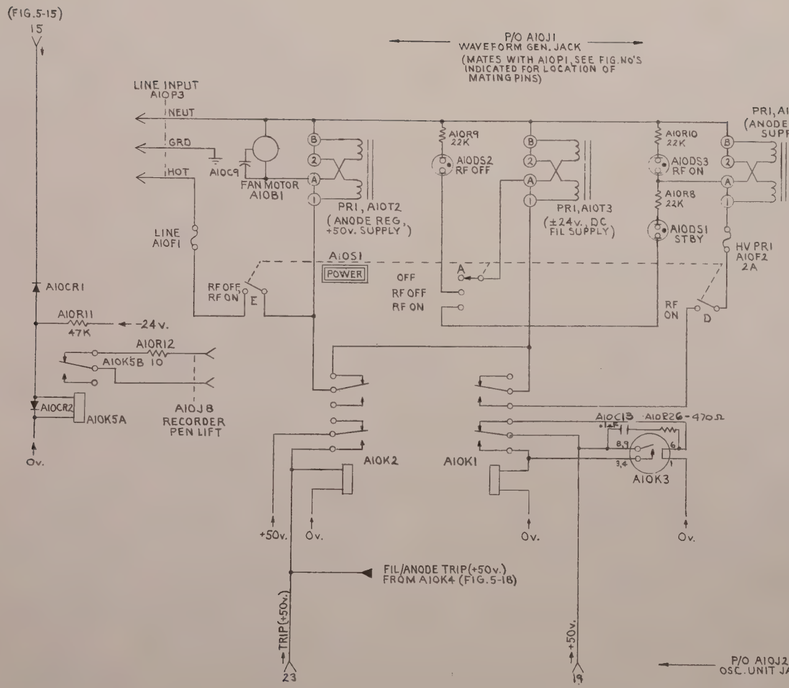


FIG. 5-22
CONTROL SCHEMATIC
MODEL 221

SECTION 6-0.
REPLACEABLE PARTS

6-1. INTRODUCTION. This section provides information for procuring replacement parts for the Model 221 Microwave Sweep Oscillator. Table 6-2 provides an alpha-numerical list, by reference designation, of all parts. The following information is given, when applicable, for each part listed:

a. Micro-Power part number.
b. Description of part.
c. Typical manufacturer and manufacturer's part number.

6-2. REFERENCE DESIGNATIONS AND ABBREVIATIONS. See Table 6-1. for a complete explanation of reference designations and abbreviations.

6-3. ORDERING INFORMATION. The following information should be included on purchase order when ordering replacement parts from the Micro-Power Corp.:

a. The Micro-Power part number and part description.
b. The instrument's model number and serial number.
c. If ordering a part not included in Table 6-2., include a complete description of the part, its function and its location within the equipment.

The following information should be included on purchase order when ordering replacement parts from another manufacturer:
The complete description of the part and manufacturer's part number for the part as they appear in Table 6-2.

TABLE 6-1

ABBREVIATIONS AND REFERENCE DESIGNATIONS

All reference designations for electrical parts will be preceded by a prefix which will indicate the assembly in which it is contained. These prefixes will be identified as follows:

A1 - Sweep Generator Printed Circuit Board Ass'y.
A2 - Sweep Amplifier Printed Circuit Board Ass'y.
A3 - Sweep Time Selector Switch Ass'y.
A4 - Sweep Output Amplitude Adjustment Ass'y.
A5 - Power Supply Printed Circuit Board Ass'y.
A6 - Helix-Anode Supply Printed Circuit Board Ass'y.
A7 - High Voltage Rectifier Printed Circuit Board Ass'y.
A8 - Grid Supply Printed Circuit Board Ass'y.
A9 - (Spare)
* A10- Basic Unit Ass'y.
** A11- Oscillator Unit Printed Circuit Board Ass'y.

* Includes all parts within the Microwave Sweep Oscillator not included in assemblies A1-A9 or in Oscillator Unit Assembly A11.
** For specific information for the Oscillator Plug-in Module see applicable Oscillator Unit Instruction Manual.

ABBREVIATIONS

A-Amperes
AMPL-Amplifier
AM-Amplitude modulation
APPROX-Approximate
ASS'Y-Assembly
AUX-Auxiliary
AVG-Average
BAL-Balance
BWO-Backward wave oscillator
C-Cathode
CAL-Calibrator
CCW-Counterclockwise
CW-Clockwise
dB-Decibel
dBM-Decibel (referred to 1 milliwatt in 600 ohms)
EXT-External
F-Farad
FIG-Figure
FIX-Fixed
FM-Frequency modulate
FWD-Forward
G-Giga=10^9
GRD-Ground
H-Henry
Hz-Cycle per second
IDENT-Identification
IMP-Impulse
INT-Internal
K-kilo=10^3
LIN-Linear
M-Milli=10^{-3}
MAX-Maximum
MEG-meg=10^6
MFG-Manufacturer
MIN-Minimum
N-Nano=10^9
NC-Normally closed
NEG-Negative
NO-Normally open
Ω-Ohm
P-Peak
PC-Printed circuit
PF-Pico farads=10^{-12} farads
P/O-Part of
POT-Potentiometer
P-P-Peak to peak
RECT-Rectifier
RES-Resistance or Resistor
RET-Return
REV-Reverse
RF-Radio frequency
RMS-Square root of mean square
SEC-Second
SW-Switch
SYM-Symmetrical
TRIG-Trigger
TYP-Typical
U-Micro=10^6
V-Volt
VAR-Variable
W-Watts

REFERENCE DESIGNATIONS

A-Assembly
B-Motor
C-Capacitor
CR-Diode
DS-Lamp
F-Fuse
J-Jack
K-Relay
L-Inductor
M-Meter
P-Plug
Q-Transistor
R-Resistor
S-Switch
T-Transformer
TB-Terminal board
TP-Test point
V-Vacuum tube
X-Socket

TABLE 6-2

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A1C1	430-024	.022uF 10% 50 VDCW Myl	84411	601PE
A1C2	430-024	.022uF 10% 50 VDCW Myl	84411	601PE
A1C3	420-035	.002uF 20% 1K VDCW Cer	56289	5GA-D20
A1C4	420-035	.002uF 20% 1K VDCW Cer	56289	5GA+D20
A1C5	430-027	.01uF 10% 50 VDCW Myl	84411	601PE
A1C6	460-681	680pF 10% 300 VDCW Mica	84171	DM-15
A1C7	420-035	.002uF 20% 1K VDCW Cer	56289	5GA-D20
A1C8	460-681	680pF 10% 300 VDCW Mica	84171	DM-15
A1C9	460-101	100pF 10% 500 VDCW Mica	84171	DM-15
A1C10	430-027	.01uF 10% 50 VDCW Myl	84411	601PE
A1C11	460-101	100pF 10% 500 VDCW Mica	84171	DM-15
A1CR1	500-005	DIODE	14099	SCE2
A1CR2	500-005	DIODE	14099	SCE2
A1CR3	500-005	DIODE	14099	SCE2
A1CR4	500-005	DIODE	14099	SCE2
A1CR5	500-005	DIODE	14099	SCE2
A1CR6	500-005	DIODE	14099	SCE2
A1CR7	500-005	DIODE	14099	SCE2
A1CR8	500-005	DIODE	14099	SCE2
A1CR9	500-005	DIODE	14099	SCE2
A1CR10	500-005	DIODE	14099	SCE2
A1CR11	500-005	DIODE	14099	SCE2
A1CR12	500-005	DIODE	14099	SCE2
A1CR13	500-010	DIODE	01295	IN914
A1CR14	500-005	DIODE	14099	SCE2
A1CR15	500-005	DIODE	14099	SCE2
A1CR16	501-013	DIODE	03877	IN749A
A1CR17	501-008	DIODE	03877	IN759
A1CR18	501-008	DIODE	03877	IN759
A1CR19	501-007	DIODE	03877	IN753A
A1CR20	500-005	DIODE	14099	SCE2
A1CR21	501-007	DIODE	03877	IN753A
A1CR22	500-005	DIODE	14099	SCE2
A1Q1	502-014	TRANSISTOR	07263	2N3645
A1Q2	502-014	TRANSISTOR	07263	2N3645
A1Q3	502-014	TRANSISTOR	07263	2N3645
A1Q4	502-014	TRANSISTOR	07263	2N3645
A1Q5	502-014	TRANSISTOR	07263	2N3645
A1Q6	502-014	TRANSISTOR	07263	2N3645
A1Q7	502-014	TRANSISTOR	07263	2N3645
A1Q8		Not Assigned		
A1Q9	502-010	TRANSISTOR	01295	2N3707
A1Q10	502-014	TRANSISTOR	07263	2N3645
A1Q11	502-010	TRANSISTOR	01295	2N3707
A1Q12	502-014	TRANSISTOR	07263	2N3645

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A1Q13	502-014	TRANSISTOR	07263	2N3645
A1Q14	502-014	TRANSISTOR	07263	2N3645
A1Q15	502-014	TRANSISTOR	07263	2N3645
A1Q16	502-014	TRANSISTOR	07263	2N3645
A1Q17	502-005	TRANSISTOR	01295	2N697
A1Q18	502-005	TRANSISTOR	01295	2N697
A1Q19	502-005	TRANSISTOR	01295	2N697
A1Q20	502-005	TRANSISTOR	01295	2N697
A1Q21	502-014	TRANSISTOR	07263	2N3645
A1Q22	502-014	TRANSISTOR	07263	2N3645
A1Q23	502-005	TRANSISTOR	01295	2N697
A1Q24	502-014	TRANSISTOR	07263	2N3645
A1R1	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R2	300-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A1R3	300-102	1K Ohm 10% 1/4 W Comp	01121	RC07GF102K
A1R4	300-104	100K Ohm 10% 1/4 W Comp	01121	RC07GF104K
A1R5	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R6	300-104	100K Ohm 10% 1/4 W Comp	01121	RC07GF104K
A1R7	300-473	47K Ohm 10% 1/4 W Comp	01121	RC07GF473K
A1R8	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R9	300-104	100K Ohm 10% 1/4 W Comp	01121	RC07GF104K
A1R10	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R11	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R12	300-333	33K Ohm 10% 1/4 W Comp	01121	RC07GF333K
A1R13	300-222	2.2K Ohm 10% 1/4 W Comp	01121	RC07GF222K
A1R14	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R15	300-104	100K Ohm 10% 1/4 W Comp	01121	RC07GF104K
A1R16	300-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A1R17	300-104	100K Ohm 10% 1/4 W Comp	01121	RC07GF104K
A1R18	300-105	1M Ohm 10% 1/4 W Comp	01121	RC07GF105K
A1R19	300-104	100K Ohm 10% 1/4 W Comp	01121	RC07GF104K
A1R20	300-332	3.3K Ohm 10% 1/4 W Comp	01121	RC07GF332K
A1R21	300-104	100K Ohm 10% 1/4 W Comp	01121	RC07GF104K
A1R22	300-332	3.3K Ohm 10% 1/4 W Comp	01121	RC07GF332K
A1R23	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A1R24	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R25	301-103	10K Ohm 10% 1/2 W Comp	01121	RC07GF103K
A1R26	315-078	5.9K Ohm 1% 1/8 W Met.Film	91637	RN60C5901F
A1R27	300-473	47K Ohm 10% 1/4 W Comp	01121	RC07GF473K
A1R28	300-153	15K Ohm 10% 1/4 W Comp	01121	RC07GF153K
A1R29	300-473	47K Ohm 10% 1/4 W Comp	01121	RC07GF473K
A1R30	315-051	147K Ohm 1% 1/8 W Met.Film	91637	RN60C1473F
A1R31		Not Assigned		
A1R32	300-222	2.2K Ohm 10% 1/4 W Comp	01121	RC07GF222K
A1R33	300-220	22 Ohm 10% 1/4 W Comp	01121	RC07GF220K
A1R34	315-055	2.49K Ohm 1% 1/8 W Met.Film	91637	RN60C2491F
A1R35	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R36	300-105	1M Ohm 10% 1/4 W Comp	01121	RC07GF105K

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A1R37	300-105	1M Ohm 10% 1/4 W Comp	01121	RC07GF105K
A1R38	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A1R39	300-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A1R40	315-092	14K Ohm 1% 1/8 W Met.Film	91637	RN60C1402F
A1R41	300-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A1R42	315-016	10.5K Ohm 1% 1/8 W Met.Film	91637	RN60C1052F
A1R43	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A1R44	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A1R45	315-031	20.5K Ohm 1% 1/8 W Met.Film	91637	RN60C2052F
A1R46	300-104	100K Ohm 10% 1/4 W Comp	01121	RC07GF104K
A1R47	315-028	16.5K Ohm 1% 1/8 W Met Film	91637	RN60C1652F
A1R48	304-022	2K Ohm 10% 1/2 W WW LinVar	91637	2387
A1R49	304-022	2K Ohm 10% 1/2 W WW LinVar	91637	2387
A1R50	315-078	5.9K Ohm 1% 1/8 W Met Film	91637	RN60C5901F
A1R51	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A1R52	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A1R53	301-332	3.3K Ohm 10% 1/2 W Comp	01121	RC07GF332K
A1R54	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R55	302-332	3.3K Ohm 10% 1 W Comp	01121	RC07GF332K
A1R56		Not Assigned		
A1R57	300-473	47K Ohm 10% 1/4 W Comp	01121	RC07GF473K
A1R58	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A1R59	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A1R60	315-082	11.3K Ohm 1% 1/8 W Met Film	91637	RN60C1132F
A1R61	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R62	300-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A1R63	315-057	8.06K Ohm 1% 1/8 W Met Film	91637	RN60C8061F
A1R64	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A1R65	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R66	302-222	2.2K Ohm 10% 1 W Comp	01121	RC07GF222K
A1R67	304-005	1K Ohm 10% 1/2 W WW LinVar	91637	2387
A1R68	304-005	1K Ohm 10% 1/2 W WW LinVar	91637	2387
A1R69	315-023	40.2K Ohm 1% 1/8 W Met Film	91637	RN60C4022F
A1R70	304-005	1K Ohm 10% 1/2 W WW LinVar	91637	2387
A1R71	315-056	4.53K Ohm 1% 1/8 W Met Film	91637	RN60C4531F
A1R72	300-682	6.8K Ohm 10% 1/4 W Comp	01121	RC07GF682K
A1R73	301-222	2.2K Ohm 10% 1/2 W Comp	01121	RC07GF222K
A1R74	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A1R75	300-471	470 Ohm 10% 1/4 W Comp	01121	RC07GF471K
A1R76	315-054	1K Ohm 1% 1/8 W Met Film	91637	RN60C1001F
A1R77	304-005	1K Ohm 10% 1/2 W WW LinVar	91637	2387
A1R78	315-054	1K Ohm 1% 1/8 W Met Film	91637	RN60C1001F
A1R79	315-018	6.65K Ohm 1% 1/8 W Met Film	91637	RN60C6651F
A1R80	315-013	2.8K Ohm 1% 1/8 W Met Film	91637	RN60C2801F
A1R81	300-222	2.2K Ohm 10% 1/4 W Comp	01121	RC07GF222K
A1R82	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A1R83	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A1R84	303-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A1R85	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A1R86	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A2C1	460-331	330 pF 10% 500 VDCW Mica	84171	DM-15
A2C2	420-040	.0047uF 20% 1K VDCW Cer	56289	5GA-D47
A2C3	460-101	100 pF 10% 500 VDCW Mica	84171	DM-15
A2C4	460-331	330 pF 10% 500 VDCW Mica	84171	DM-15
A2C5	460-101	100 pF 10% 500 VDCW Mica	84171	DM-15
A2C6	460-101	100 pF 10% 500 VDCW Mica	84171	DM-15
A2C7	460-331	330 pF 10% 500 VDCW Mica	84171	DM-15
A2C8	460-101	100 pF 10% 500 VDCW Mica	84171	DM-15
A2C9	460-101	100 pF 10% 500 VDCW Mica	84171	DM-15
A2C10	460-331	330 pF 10% 500 VDCW Mica	84171	DM-15
A2C11	460-681	680 pF 10% 300 VDCW Mica	84171	DM-15
A2C12	460-681	680 pF 10% 300 VDCW Mica	84171	DM-15
A2C13	430-034	.022 uF 5% 50 VDCW Myl	84411	601PE
A2C14	430-034	.022 uF 5% 50 VDCW Myl	84411	601PE
A2C15	460-681	680 pF 10% 300 VDCW Mica	84171	DM-15
A2C16	460-221	220 pF 10% 500 VDCW Mica	84171	DM-15
A2CR1	501-007	DIODE	03877	IN753A
A2CR2	501-013	DIODE	03877	IN749A
A2CR3	501-007	DIODE	03877	IN753A
A2CR4	500-005	DIODE	14099	SCE2
A2CR5	500-005	DIODE	14099	SCE2
A2CR6	500-005	DIODE	14099	SCE2
A2CR7	500-005	DIODE	14099	SCE2
A2CR8	501-007	DIODE	03877	IN753A
A2CR9	500-005	DIODE	14099	SCE2
A2CR10	500-005	DIODE	14099	SCE2
A2CR11	500-005	DIODE	14099	SCE2
A2CR12	500-005	DIODE	14099	SCE2
A2CR13	500-005	DIODE	14099	SCE2
A2CR14	500-005	DIODE	14099	SCE2
A2CR15	500-005	DIODE	14099	SCE2
A2Q1	502-005	TRANSISTOR	01295	2N697
A2Q2	502-005	TRANSISTOR	01295	2N697
A2Q3	502-010	TRANSISTOR	01295	2N3707
A2Q4	502-005	TRANSISTOR	01295	2N697
A2Q5	502-014	TRANSISTOR	07263	2N3645
A2Q6	502-014	TRANSISTOR	07263	2N3645
A2Q7	502-014	TRANSISTOR	07263	2N3645
A2Q8	502-010	TRANSISTOR	01295	2N3707
A2Q9	502-010	TRANSISTOR	01295	2N3707
A2Q10	502-005	TRANSISTOR	01295	2N697
A2Q11	502-005	TRANSISTOR	01295	2N697
A2Q12	502-005	TRANSISTOR	01295	2N697
A2Q13	502-005	TRANSISTOR	01295	2N697

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A2Q14	502-005	TRANSISTOR	01295	2N697
A2Q15	502-010	TRANSISTOR	01295	2N3707
A2Q16	502-010	TRANSISTOR	01295	2N3707
A2Q17	502-005	TRANSISTOR	01295	2N697
A2Q18	502-005	TRANSISTOR	01295	2N697
A2Q19	502-005	TRANSISTOR	01295	2N697
A2Q20	502-005	TRANSISTOR	01295	2N697
A2Q21	502-005	TRANSISTOR	01295	2N697
A2Q22	502-005	TRANSISTOR	01295	2N697
A2Q23	502-014	TRANSISTOR	07263	2N3645
A2Q24	502-014	TRANSISTOR	07263	2N3645
A2Q25	502-014	TRANSISTOR	07263	2N3645
A2R1	304-005	1K Ohm 10% 1/2 W WW LinVar	91637	2387
A2R2	304-005	1K Ohm 10% 1/2 W WW LinVar	91637	2387
A2R3	315-005	69.08 Ohm 1% 1/8 W Met Film	91637	RN60C6982F
A2R4	315-015	6.98K Ohm 1% 1/8 W Met Film	91637	RN60C6981F
A2R5	315-015	6.98K Ohm 1% 1/8 W Met Film	91637	RN6066981F
A2R6	315-005	69.8 Ohm 1% 1/8 W Met Film	91637	RN60C6982F
A2R7	315-060	100 Ohm 1% 1/8 W Met Film	91637	RN60C1000F
A2R8	315-016	10.5K Ohm 1% 1/8 W Met Film	91637	RN60C1052F
A2R9	315-016	10.5K Ohm 1% 1/8 W Met Film	91637	RN60C1052F
A2R10	315-060	100 Ohm 1% 1/8 W Met Film	91637	RN60C1000F
A2R11	300-473	47K Ohm 10% 1/4 W Comp	01121	RCO7GF473K
A2R12	300-104	100K Ohm 10% 1/4 W Comp	01121	RCO7GF104K
A2R13	300-102	1K Ohm 10% 1/4 W Comp	01121	RCO7GF102K
A2R14	300-101	100 Ohm 10% 1/4 W Comp	01121	RCO7GF101K
A2R15	315-016	10.5K Ohm 1% 1/8 W Met Film	91637	RN60C1052F
A2R16	300-683	68K Ohm 10% 1/4 W Comp	01121	RCO7GF683K
A2R17	300-474	470K Ohm 10% 1/4 W Comp	01121	RCO7GF474K
A2R18	300-473	47K Ohm 10% 1/4 W Comp	01121	RCO7GF473K
A2R19	304-005	1K Ohm 10% 1/2 W WW LinVar	91637	2387
A2R20		0 Ohm		
A2R21	300-223	22K Ohm 10% 1/4 W Comp	01121	RCO7GF223K
A2R22	315-061	10K Ohm 1% 1/8 W Met Film	91637	RN60C1002F
A2R23	305-039	20K Ohm .1% .15 W WW	91637	WWA-22
A2R24	305-037	24K Ohm .1% .15 W WW	91637	WWA-22
A2R25	300-153	15K Ohm 10% 1/4 W Comp	01121	RCO7GF153K
A2R26	305-037	24K Ohm .1% .15 W WW	91637	WWA-22
A2R27	315-068	20K Ohm 1% 1/8 W Met Film	91637	RN60C2002F
A2R28	305-036	10K Ohm .1% .15 W WW	91637	WWA-22
A2R29	305-036	10K Ohm .1% .15 W WW	91637	WWA-22
A2R30	305-037	24K Ohm .1% .15 W WW	91637	WWA-22
A2R31	315-068	20K Ohm 1% 1/8 W Met Film	91637	RN60C2002F
A2R32	303-222	2.2K Ohm 10% 2 W Comp	01121	RCO7GF222K
A2R33	300-102	1K Ohm 10% 1/4 W Comp	01121	RCO7GF102K
A2R34	300-333	33K Ohm 10% 1/4 W Comp	01121	RCO7GF333K
A2R35	300-101	100 Ohm 10% 1/4 W Comp	01121	RCO7GF101K
A2R36	300-473	47K Ohm 10% 1/4 W Comp	01121	RCO7GF473K

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A2R37	300-683	68K Ohm 10% 1/4 W Comp	01121	RC07GF683K
A2R38	300-333	33K Ohm 10% 1/4 W Comp	01121	RC07GF333K
A2R39	304-005	1K Ohm 10% 1/2 W WW LinVar	91637	2387
A2R40	315-015	6.98K Ohm 1% 1/8 W Met Film	91637	RN60C6981F
A2R41	315-004	34.8 Ohm 1% 1/8 W Met Film	91637	RN60C3482F
A2R42	315-004	34.8 Ohm 1% 1/8 W Met Film	91637	RN60C3482F
A2R43	315-015	6.98K Ohm 1% 1/8 W Met Film	91637	RN60C6981F
A2R44	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A2R45	315-021	33.2K Ohm 1% 1/8 W Met Film	91637	RN60C3322F
A2R46	300-104	100K Ohm 10% 1/4 W Comp	01121	RC07GF104K
A2R47	300-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A2R48	315-021	33.2K Ohm 1% 1/8 W Met Film	91637	RN60C3322F
A2R49	300-332	3.3K Ohm 10% 1/4 W Comp	01121	RC07GF332K
A2R50	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A2R51	300-332	3.3K Ohm 10% 1/4 W Comp	01121	RC07GF332K
A2R52	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A2R53	315-021	33.2K Ohm 1% 1/8 W Met Film	91637	RN60C3322F
A2R54	300-102	1K Ohm 10% 1/4 W Comp	01121	RC07GF102K
A2R55	300-102	1K Ohm 10% 1/4 W Comp	01121	RC07GF102K
A2R56	300-333	33K Ohm 10% 1/4 W Comp	01121	RC07GF332K
A2R57	315-016	10.5K Ohm 1% 1/8 W Met Film	91637	RN60C1052F
A2R58	315-057	8.06K Ohm 1% 1/8 W Met Film	91637	RN60C8061F
A2R59	315-057	8.06K Ohm 1% 1/8 W Met Film	91637	RN60C8061F
A2R60	315-015	6.98K Ohm 1% 1/8 W Met Film	91637	RN60C6981F
A2R61	315-004	34.8 Ohm 1% 1/8 W Met Film	91637	RN60C3480F
A2R62	315-004	34.8 Ohm 1% 1/8 W Met Film	91637	RN60C3480F
A2R63	315-015	6.98K Ohm 1% 1/8 W Met Film	91637	RN60C6982F
A2R64	304-005	1K Ohm 10% 1/2 W WW LinVar	91637	2387
A2R65	300-473	47K Ohm 10% 1/4 W Comp	01121	RC07GF473K
A2R66	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A2R67	315-021	33.2K Ohm 1% 1/8 W Met Film	91637	RN60C3322F
A2R68	300-104	100K Ohm 10% 1/4 W Comp	01121	RC07GF104K
A2R69	300-683	68K Ohm 10% 1/4 W Comp	01121	RC07GF683K
A2R70	300-333	33K Ohm 10% 1/4 W Comp	01121	RC07GF333K
A2R71	300-102	1K Ohm 10% 1/4 W Comp	01121	RC07GF102K
A2R72	300-473	47K Ohm 10% 1/4 W Comp	01121	RC07GF473K
A2R73	300-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A2R74	315-021	33.2K Ohm 1% 1/8 W Met Film	91637	RN60C3322F
A2R75	315-021	33.2K Ohm 1% 1/8 W Met Film	91637	RN60C3322F
A2R76	300-332	3.3K Ohm 10% 1/4 W Comp	01121	RC07GF332K
A2R77	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A2R78	300-332	3.3K Ohm 10% 1/4 W Comp	01121	RC07GF332K
A2R79	300-223	22K Ohm 10% 1/4 W Comp	01121	RC07GF223K
A2R80	300-102	1K Ohm 10% 1/4 W Comp	01121	RC07GF102K
A2R81	300-102	1K Ohm 10% 1/4 W Comp	01121	RC07GF102K
A2R82	300-333	33K Ohm 10% 1/4 W Comp	01121	RC07GF333K
A2R83	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A2R84	300-332	3.3K Ohm 10% 1/4 W Comp	01121	RC07GF332K
A2R85	300-332	3.3K Ohm 10% 1/4 W Comp	01121	RC07GF332K
A2R86	300-471	470 Ohm 10% 1/4 W Comp	01121	RC07GF471K
A2R87	300-471	470 Ohm 10% 1/4 W Comp	01121	RC07GF471K

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A2R88	315-020	49.9K Ohm 1% 1/8 W Met Film	91637	RN60C4992F
A2R89	315-020	49.9K Ohm 1% 1/8 W Met Film	91637	RN60C4992F
A2R90	300-222	2.2K Ohm 10% 1/4 W Comp	01121	RCO7GF222K
A3C1	440-042	100uF 20% 20VDCW Tant	56289	150D107x 0020S2
A3C2	440-040	10uF 20% 20VDCW Tant	56289	150D106x 0020B2
A3C3	440-041	1uF 20% 20VDCW Tant	56289	150D105x 0020A2
A3C4	430-011	.1uF 10% 50VDCW Myl	84411	601PE
A3R1	P/O A3S1	1K Ohm 30% 1/2 W Comp Var		
A3R2	P/O A3S1	1M Ohm 10% 1/8 W Comp Var		
A3S1	210-015	Switch Rotary, Assembly	18786	
A4C1	420-040	.0047uF 20% 1K VDCW Cer	56289	5GA-D47
A4R1	304-010	10K Ohm 10% 1/2 W Comp Lin Var	18786	
A4R2	300-332	3.3K Ohm 10% 1/4 W Comp	01121	RCO7GF332K
A4R3	300-103	10K Ohm 10% 1/4 W Comp	01121	RCO7GF103K
A5C1	400-029	60uF -10+100% 75 VDCW Elect	Tenn E	
A5C2	430-032	.22uF 10% 50 VDCW Myl	84411	601PE
A5C3	430-017	.047uF 10% 50 VDCW Myl	84411	601PE
A5C4	430-011	.1uF 10% 50 VDCW Myl	84411	601PE
A5C5	430-011	.1uF 10% 50 VDCW Myl	84411	601PE
A5C6	430-017	.047uF 10% 50 VDCW Myl	84411	601PE
A5C7	400-041	100uF -10+100% 25 VDCW Elect	56289	TE-1211
A5C8	420-023	.1uF GMV 500 VDCW Cer	56289	SHK-P10
A5C9	420-023	.1uF GMV 500 VDCW Cer	56289	SHK-P10
A5C10	400-041	100uF -10+100% 25 VDCW Elect	56289	TE-1211
A5C11	440-040	10uF 20% 20 VDCW Tant	56289	150D106x 0020B2
A5C12	400-009	20uF -10+100% 50 VDCW Elect	56289	TE-1305
A5C13	430-032	.22uF 10% 50 VDCW Myl	84411	601PE
A5C14	430-024	.022uF 10% 50 VDCW Myl	84411	601PE
A5C15	400-041	100uF -10+100% 25 VDCW Elect	56289	TE-1211
A5C16	440-040	10uF 20% 20 VDCW Tant	56289	150D106x 0020B2

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A5C17	400-009	20uF -10+100% 50 VDCW Elect	56289	TE-1305
A5C18	430-032	.22uF 10% 50 VDCW Myl	84411	601PE
A5C19	430-024	.22uF 10% 50 VDCW Myl	84411	601PE
A5CR1	500-009	DIODE	02735	IN1199A
A5CR2	500-009	DIODE	02735	IN1199A
A5CR3	501-007	DIODE	03877	IN753A
A5CR4	501-008	DIODE	03877	IN759
A5CR5	501-007	DIODE	03877	IN753A
A5CR6	501-008	DIODE	03877	IN759
A5CR7	501-008	DIODE	03877	IN759
A5CR8	501-007	DIODE	03877	IN753A
A5CR9	501-007	DIODE	03877	IN753A
A5CR10	500-005	DIODE	14099	SCE2
A5CR11	500-005	DIODE	14099	SCE2
A5CR12	500-005	DIODE	14099	SCE2
A5CR13	500-005	DIODE	14099	SCE2
A5CR14	501-012	DIODE	03877	IN3496
A5CR15	501-008	DIODE	03877	IN759
A5CR16	500-005	DIODE	14099	SCE2
A5CR17	500-005	DIODE	14099	SCE2
A5CR18	500-005	DIODE	14099	SCE2
A5CR19	500-005	DIODE	14099	SCE2
A5CR20	500-005	DIODE	14099	SCE2
A5CR21	500-005	DIODE	14099	SCE2
A5CR22	500-005	DIODE	14099	SCE2
A5CR23	500-005	DIODE	14099	SCE2
A5CR24	501-008	DIODE	03877	IN759
A5CR25	501-007	DIODE	03877	IN753A
A5CR26	501-012	DIODE	03877	IN3496
A5CR27	501-008	DIODE	03877	IN759
A5CR28	500-005	DIODE	14099	SCE2
A5CR29	500-005	DIODE	14099	SCE2
A5CR30	500-005	DIODE	14099	SCE2
A5CR31	500-005	DIODE	14099	SCE2
A5CR32	500-005	DIODE	14099	SCE2
A5CR33	500-005	DIODE	14099	SCE2
A5CR34	500-005	DIODE	14099	SCE2
A5CR35	500-005	DIODE	14099	SCE2
A5CR36	501-007	DIODE	03877	IN753A
A5CR37	501-008	DIODE	03877	IN759
A5Q1	502-007	TRANSISTOR	01295	2N1131
A5Q2	502-005	TRANSISTOR	01295	2N697
A5Q3	502-014	TRANSISTOR	07263	2N3645
A5Q4	502-005	TRANSISTOR	01295	2N697
A5Q5	502-007	TRANSISTOR	01295	2N1131

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description				Code Ident	Mfg No
A5Q6	502-007	TRANSISTOR				01295	2N1131
A5Q7	502-015	TRANSISTOR				03508	2N2913
A5Q8	502-005	TRANSISTOR				01295	2N697
A5Q9	502-014	TRANSISTOR				07263	2N3645
A5Q10	502-007	TRANSISTOR				01295	2N1131
A5Q11	502-015	TRANSISTOR				03508	2N2913
A5Q12	502-005	TRANSISTOR				01295	2N697
A5Q13	502-014	TRANSISTOR				07263	2N3645
A5Q14	502-007	TRANSISTOR				01295	2N1131
A5R1	303-102	1K Ohm	10%	2 W	Comp	01121	RC42GF102K
A5R2	300-472	4.7K Ohm	10%	1/4 W	Comp	01121	RC07GF472K
A5R3	300-471	470 Ohm	10%	1/4 W	Comp	01121	RC07GF471K
A5R4	300-223	22K Ohm	10%	1/4 W	Comp	01121	RC07GF223K
A5R5	300-220	22 Ohm	10%	1/4 W	Comp	01121	RC07GF220K
A5R6	300-102	1K Ohm	10%	1/4 W	Comp	01121	RC07GF102K
A5R7	300-472	4.7K Ohm	10%	1/4 W	Comp	01121	RC07GF472K
A5R8	300-103	10K Ohm	10%	1/4 W	Comp	01121	RC07GF103K
A5R9	300-102	1K Ohm	10%	1/4 W	Comp	01121	RC07GF102K
A5R10	303-102	1K Ohm	10%	2 W	Comp	01121	RC42GF102K
A5R11	300-222	2.2K Ohm	10%	1/4 W	Comp	01121	RC07GF222K
A5R12	300-471	470 Ohm	10%	1/4 W	Comp	01121	RC07GF471K
A5R13	300-102	1K Ohm	10%	1/4 W	Comp	01121	RC07GF102K
A5R14	300-471	470 Ohm	10%	1/4 W	Comp	01121	RC07GF471K
A5R15	300-102	1K Ohm	10%	1/4 W	Comp	01121	RC07GF102K
A5R16	300-471	470 Ohm	10%	1/4 W	Comp	01121	RC07GF471K
A5R17	315-055	2.49K Ohm	1%	1/8 W	Met Film	91637	RN60C2491F
A5R18	304-018	1K Ohm	20%	1/4 W	Comp Lin Var	71450	U201
A5R19	304-024	1K Ohm	15%	1/4 W	WW LinVar	91637	399
A5R20	315-078	5.9K Ohm	1%	1/8 W	Met Film	91637	RN60C5901F
A5R21	300-103	10K Ohm	10%	1/4 W	Comp	01121	RC07GF103K
A5R22	301-222	2.2K Ohm	10%	1/2 W	Comp	01121	RC20GF222K
A5R23	300-472	4.7K Ohm	10%	1/4 W	Comp	01121	RC07GF472K
A5R24	300-102	1K Ohm	10%	1/4 W	Comp	01121	RC07GF102K
A5R25	300-333	33K Ohm	10%	1/4 W	Comp	01121	RC07GF333K
A5R26	300-102	1K Ohm	10%	1/4 W	Comp	01121	RC07GF102K
A5R27	300-472	4.7K Ohm	10%	1/4 W	Comp	01121	RC07GF472K
A5R28	300-222	2.2K Ohm	10%	1/4 W	Comp	01121	RC07GF222K
A5R29	302-222	2.2K Ohm	10%	1 W	Comp	01121	RC32GF222K
A5R30	300-470	47 Ohm	10%	1/4 W	Comp	01121	RC07GF470K
A5R31	300-222	2.2K Ohm	10%	1/4 W	Comp	01121	RC07GF222K
A5R32	300-101	100 Ohm	10%	1/4 W	Comp	01121	RC07GF101K
A5R33	315-070	17.8K Ohm	1%	1/8 W	Met Film	91637	RN60C1782F
A5R34	300-332	3.3K Ohm	10%	1/4 W	Comp	01121	RC07GF332K
A5R35	302-222	2.2K Ohm	10%	1 W	Comp	01121	RC07GF222K
A5R36	304-024	1K Ohm	15%	1/4 W	WW LinVar	91637	399
A5R37	315-078	5.9K Ohm	1%	1/8 W	Met Film	91637	RN60C5901F

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A5R38	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A5R39	301-222	2.2K Ohm 10% 1/2 W Comp	01121	RC20GF222K
A5R40	300-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A5R41	300-102	1K Ohm 10% 1/4 W Comp	01121	RC07GF102K
A5R42	300-333	33K Ohm 10% 1/4 W Comp	01121	RC07GF333K
A5R43	300-102	1K Ohm 10% 1/4 W Comp	01121	RC07GF102K
A5R44	300-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A5R45	300-222	2.2K Ohm 10% 1/4 W Comp	01121	RC07GF222K
A5R46	302-222	2.2K Ohm 10% 1 W Comp	01121	RC32GF222K
A5R47	300-470	47 Ohm 10% 1/4 W Comp	01121	RC07GF470K
A5R48	300-222	2.2K Ohm 10% 1/4 W Comp	01121	RC07GF222K
A5R49	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A5R50	315-070	17.8K Ohm 1% 1/8 W Met Film	91637	RN60C1782F
A5R51	302-222	2.2K Ohm 10% 1 W Comp	01121	RC32GF222K
A5R52	300-152	1.5K Ohm 10% 1/4 W Comp	01121	RC07GF152K
A5R53	300-102	1K Ohm 10% 1/4 W Comp	01121	RC07GF102K
A6C1	400-029	60uF -10+100% 75 VDCW Elect	TennE	
A6C2	430-024	.022uF 10% 50 VDCW Myl	84411	601PE
A6C3	400-029	60uF -10+100% 75 VDCW Elect	TennE	
A6C4	400-029	60uF -10+100% 75 VDCW Elect	TennE	
A6CR1	500-005	DIODE	14099	SCE2
A6CR2	500-005	DIODE	14099	SCE2
A6CR3	500-005	DIODE	14099	SCE2
A6CR4	500-005	DIODE	14099	SCE2
A6CR5	501-008	DIODE	03877	IN759
A6CR6	501-007	DIODE	03877	IN753A
A6CR7	501-007	DIODE	03877	IN753A
A6CR8	500-005	DIODE	14099	SCE2
A6CR9	500-005	DIODE	14099	SCE2
A6CR10	500-005	DIODE	14099	SCE2
A6CR11	501-007	DIODE	03877	IN753A
A6CR12	501-008	DIODE	03877	IN759
A6CR13	500-005	DIODE	14099	SCE2
A6CR14	500-005	DIODE	14099	SCE2
A6Q1	502-014	TRANSISTOR	07263	2N3645
A6Q2	502-005	TRANSISTOR	01295	2N697
A6Q3	502-005	TRANSISTOR	01295	2N697
A6R1	303-222	2.2K Ohm 10% 2 W Comp	01121	RC42GF222K
A6R2	300-152	1.5K Ohm 10% 1/4 W Comp	01121	RC07GF152K

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A6R3	315-045	2.37K Ohm 1% 1/8 W Met Film	91637	RN60C2371F
A6R4	315-081	3.01K Ohm 1% 1/8 W Met Film	91637	RN60C3011F
A6R5	302-103	10K Ohm 10% 1 W Comp	01121	RC32GF103K
A6R6	300-102	1K Ohm 10% 1/4 W Comp	01121	RC07GF102K
A6R7	300-154	150K Ohm 10% 1/4 W Comp	01121	RC07GF154K
A6R8	300-331	330 Ohm 10% 1/4 W Comp	01121	RC07GF331K
A6R9	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A6R10	300-471	470 Ohm 10% 1/4 W Comp	01121	RC07GF471K
A6R11	300-472	4.7K Ohm 10% 1/4 W Comp	01121	RC07GF472K
A6R12	304-023	2K Ohm 20% 1/4 W Comp Lin Var	71450	U201
A6R13	300-221	220 Ohm 10% 1/4 W Comp	01121	RC07GF221K
A6R14	300-221	220 Ohm 10% 1/4 W Comp	01121	RC07GF221K
A6R15	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A6R16	300-221	220 Ohm 10% 1/4 W Comp	01121	RC07GF221K
A6R17	300-221	220 Ohm 10% 1/4 W Comp	01121	RC07GF221K
A6R18	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A6R19	300-221	220 Ohm 10% 1/4 W Comp	01121	RC07GF221K
A6R20	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A6R21	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A6R22	300-221	220 Ohm 10% 1/4 W Comp	01121	RC07GF221K
A6R23	300-221	220 Ohm 10% 1/4 W Comp	01121	RC07GF221K
A6R24	300-683	68K Ohm 10% 1/4 W Comp	01121	RC07GF683K
A6R25	300-221	220 Ohm 10% 1/4 W Comp	01121	RC07GF221K
A6V1	550-004	VACUUM TUBE	33173	8068
A6V2	550-004	VACUUM TUBE	33173	8068
A6V3	550-004	VACUUM TUBE	33173	8068
A6V4	550-004	VACUUM TUBE	33173	8068
A7C1	420-005	.0025uF -0+100% 6K VDCW Cer	71590	DA-111-015
A7C2	420-005	.0025uF -0+100% 6K VDCW Cer	71590	DA-111-015
A7C3	420-005	.0025uF -0+100% 6K VDCW Cer	71590	DA-111-015
A7C4	420-005	.0025uF -0+100% 6K VDCW Cer	71590	DA-111-015
A7CR1	500-008	DIODE	01295	U443
A7CR2	500-008	DIODE	01295	U443
A7CR3	500-008	DIODE	01295	U443
A7CR4	500-008	DIODE	01295	U443
A7CR5	500-008	DIODE	01295	U443
A7CR6	500-008	DIODE	01295	U443
A7CR7	500-008	DIODE	01295	U443
A7CR8	500-008	DIODE	01295	U443
A7CR9	500-008	DIODE	01295	U443

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A7CR10	500-008	DIODE	01295	U443
A7CR11	500-008	DIODE	01295	U443
A7CR12	500-008	DIODE	01295	U443
A7CR13	500-008	DIODE	01295	U443
A7CR14	500-008	DIODE	01295	U443
A7CR15	500-008	DIODE	01295	U443
A7CR16	500-008	DIODE	01295	U443
A7CR17	500-008	DIODE	01295	U443
A7CR18	500-008	DIODE	01295	U443
A7CR19	500-008	DIODE	01295	U443
A7CR20	500-008	DIODE	01295	U443
A7CR21	500-008	DIODE	01295	U443
A7CR22	500-008	DIODE	01295	U443
A7CR23	500-008	DIODE	01295	U443
A7CR24	500-008	DIODE	01295	U443
A7R1	306-005	25K Ohm 3% 10 W WW	91637	RS-10
A7R2	306-005	25K Ohm 3% 10 W WW	91637	RS-10
A7R3	306-005	25K Ohm 3% 10 W WW	91637	RS-10
A7R4	303-102	1K Ohm 10% 2 W Comp	01121	RC42GF102K
A7R5	303-102	1K Ohm 10% 2 W Comp	01121	RC42GF102K
A7R6	303-474	470K Ohm 10% 2 W Comp	01121	RC42GF474K
A7R7	303-474	470K Ohm 10% 2 W Comp	01121	RC42GF474K
A7R8	303-474	470K Ohm 10% 2 W Comp	01121	RC42GF474K
A7R9	303-474	470K Ohm 10% 2 W Comp	01121	RC42GF474K
A7R10	303-474	470K Ohm 10% 2 W Comp	01121	RC42GF474K
A7R11	303-474	470K Ohm 10% 2 W Comp	01121	RC42GF474K
A7R12	303-102	1K Ohm 10% 2 W Comp	01121	RC42GF102K
A7R13	303-102	1K Ohm 10% 2 W Comp	01121	RC42GF102K
A7R14	303-332	3.3K Ohm 10% 2 W Comp	01121	RC42GF332K
A7R15	303-332	3.3K Ohm 10% 2 W Comp	01121	RC42GF332K
A7R16	303-332	3.3K Ohm 10% 2 W Comp	01121	RC42GF332K
A8C1	420-041	100pF 20% 3K VDCW Cer	71590	DD30-101
A8C2	420-041	100pF 20% 3K VDCW Cer	71590	DD30-101
A8C3	430-011	.1uF 10% 50 VDCW Myl	84411	601PE
A8C4	460-220	22pF 10% 500 VDCW Mica	84171	DM-15
A8C5	430-011	.1uF 10% 50 VDCW Myl	84411	601PE
A8C6	400-041	100uF -10+100% 25 VDCW Elect	56289	TE-1211
A8C7	430-011	.1uF 10% 50 VDCW Myl	84411	601PE
A8C8	460-150	15pF 10% 500 VDCW Mica	84171	DM-15
A8C9	460-220	22pF 10% 500 VDCW Mica	84171	DM-15
A8C10	460-680	68pF 10% 500 VDCW Mica	84171	DM-15
A8C11	460-330	33pF 10% 500 VDCW Mica	84171	DM-15
A8C12	430-011	.1uF 10% 50 VDCW Myl	84411	601PE
A8C13	430-011	.1uF 10% 50 VDCW Myl	84411	601PE

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A8C14	460-330	33pF 10% 500 VDCW Mica	84171	DM-15
A8C15	430-017	.047uF 10% 50 VDCW Myl	84411	601PE
A8C16	460-101	100pF 10% 500 VDCW Mica	84171	DM-15
A8C17	421-040	4.5-25pF Var 500 VDCW Cer	71590	825-AC (CV11A250)
A8CR1	500-010	DIODE	01295	IN914
A8CR2	500-010	DIODE	01295	IN914
A8CR3	500-010	DIODE	01295	IN914
A8CR4	500-010	DIODE	01295	IN914
A8CR5	500-010	DIODE	01295	IN914
A8CR6	500-010	DIODE	01295	IN914
A8L1	390-102	1000uH 10%	72259	Wee-Wee 1000
A8L2	390-680	68uH 5%	78526	Dink-68
A8L3	391-001	Ferrite Bead	95265	R45-12
A8L4	390-680	68uH 5%	78526	Dink-68
A8L5	391-001	Ferrite Bead	95265	R45-12
A8L6	390-471	470uH 5%	78526	Dink-470
A8L7	390-680	68uH 5%	78526	Dink-68
A8L8	391-001	Ferrite Bead	95265	R45-12
A8Q1	502-014	TRANSISTOR	07263	2N3645
A8Q2	502-007	TRANSISTOR	01295	2N1131
A8Q3	502-005	TRANSISTOR	01295	2N697
A8Q4	502-005	TRANSISTOR	01295	2N697
A8R1	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A8R2	300-103	10K Ohm 10% 1/4 W Comp	01121	RC07GF103K
A8R3	303-102	1K Ohm 10% 2 W Comp	01121	RC42GF102K
A8R4	300-027	2.7 Ohm 10% 1/4 W Comp	01121	RC07GF2R7K
A8R5	300-100	10 Ohm 10% 1/4 W Comp	01121	RC07GF100K
A8R6	300-332	3.3K Ohm 10% 1/4 W Comp	01121	RC07GF332K
A8R7	300-331	330 Ohm 10% 1/4 W Comp	01121	RC07GF331K
A8R8	300-101	100 Ohm 10% 1/4 W Comp	01121	RC07GF101K
A8R9	300-221	220 Ohm 10% 1/4 W Comp	01121	RC07GF221K
A8T1	392-001	Transformer, Voltage	18786	
A8T2	392-002	Transformer, Oscillator	18786	

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A10B1	230-004	Fan	82877	Gold Seal Muffin Filter Fan
A10B1	230-006	Fan (50-400Hz only)	92702	BC2206F-2
A10C1	400-040	17000uF -10+100% 15 VDCW Elect	01002	43F3067MA3
A10C2	400-042	500uF -10+100% 50 VDCW Elect	56289	39D507 G050GL4
A10C3	400-042	500uF -10+100% 50 VDCW Elect	56289	39D507 G050GL4
A10C4	410-040	.25uF 10% 5K VDCW Paper	18786	
A10C5	410-040	.25uF 10% 5K VDCW Paper	18786	
A10C6	450-031	.33uF 10% 1K VDCW Paper	56289	161P
A10C7	450-031	.33uF 10% 1K VDCW Paper	56289	161P
A10C8	400-009	20uF -10+100% 50 VDCW Elect	56289	TE-1407
A10C9	450-032	1uF 10% 600 VDCW Paper (50-400Hz only)	56289	6TM-M1
A10C10	420-040	.0047uF 20% 1K VDCW Cer	56289	5GA-D47
A10C11	460-221	220pF 10% 500 VDCW Mica	84171	DM-15
A10C12	460-151	150pF 10% 500 VDCW Mica	84171	DM-15
A10C13	420-023	.1uF 10% 500 VDCW Cer	56289	5HK-P10
A10CR1	500-005	DIODE	14099	SCE2
A10CR2	500-010	DIODE	01295	IN914
A10CR3	501-008	DIODE	03877	IN759
A10CR4	501-008	DIODE	03877	IN759
A10CR5	500-005	DIODE	14099	SCE2
A10CR6	500-005	DIODE	14099	SCE2
A10CR7	500-005	DIODE	14099	SCE2
A10CR8	500-005	DIODE	14099	SCE2
A10CR9	500-005	DIODE	14099	SCE2
A10CR10	500-005	DIODE	14099	SCE2
A10CR11	500-005	DIODE	14099	SCE2
A10DS1	214-006	Indicator	07137	MCL-A-2-NE2E
A10DS2	214-006	Indicator	07137	MCL-A-2-NE2E
A10DS3	214-006	Indicator	07137	MCL-A-2-NE2E
A10DS4	214-006	Indicator	07137	MCL-A-2-NE2E
A10F1	212-002	3A Instantaneous (115V Line)	75915	312-003
A10F1	212-004	2A Instantaneous (230V Line)	75915	312-002
A10F2	212-004	2A Instantaneous	75915	312-002
A10F3	212-005	1A Instantaneous	75915	312-001
A10F4	212-005	1A Instantaneous	75915	312-001

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description	Code Ident	Mfg No
A10IC1	503-001	Integrated Circuit	01295	SN72709N
A10J1	234-005	Connector	13511	26-190-32
A10J2	234-005	Connector	13511	26-190-32
A10J3	234-003	Connector	81862	UG1094A/U
A10J4	234-003	Connector	81862	UG1094A/U
A10J5	234-003	Connector	81862	UG1094A/U
A10J6	234-003	Connector	81862	UG1094A/U
A10J7	234-003	Connector	81862	UG1094A/U
A10J8	234-018	Binding Post	58474	DF21BC
A10J9	234-003	Connector	81862	UG1094A/U
A10J10	234-003	Connector	81862	UG1094A/U
A10K1	211-001	DPDT Relay	07065	MK02A-115V
A10K2	211-001	DPDT Relay	07065	MK02A-115V
A10K3	211-004	Thermal Delay	70563	50N060T
A10K4A	216-001	Relay Coil	18786	
A10K4B	211-010	Relay Contact SPST Reed	95348	MR700 (50-64A-T)
A10K5A	216-001	Relay Coil	18786	
A10K5B	211-008	Relay Contact SPDT Reed	95348	MR200-1 (25-44A-T)
A10P1	234-004	Connector	13511	26-159-32
A10P2		Not Assigned		
A10P3	234-017	Line Cord Receptacle, 3 Wire	87930	1065-1
A10Q1	502-008	TRANSISTOR	16758	2N441
A10Q2	502-008	TRANSISTOR	16758	2N441
A10Q3	502-008	TRANSISTOR	16758	2N441
A10Q4	502-016	TRANSISTOR	07263	2N3568
A10Q5	502-016	TRANSISTOR	07263	2N3568
A10Q6	502-014	TRANSISTOR	07263	2N3645
A10R1	304-010	10K Ohm 10% 1/2 W Comp Lin Var	18786	
A10R2	304-010	10K Ohm 10% 1/2 W Comp Lin Var	18786	
A10R3	304-008	1K Ohm 5% 2 W WW Lin Var	18786	

TABLE 6-2 (CONT'D)

REPLACEABLE PARTS

Reference Designation	Micro-Power Part Number	Description				Code Ident	Mfg No
A10R4	304-008	1K Ohm	5%	2 W	WW Lin Var	18786	
A10R5	304-008	1K Ohm	5%	2 W	WW Lin Var	18786	
A10R6	304-008	1K Ohm	5%	2 W	WW Lin Var	18786	
A10R7	305-026	1M Ohm	1%	2 W	C Film	91637	DC-2
A10R8	300-223	22K Ohm	10%	1/4 W	Comp	01121	RC07GF223K
A10R9	300-223	22K Ohm	10%	1/4 W	Comp	01121	RC07GF223K
A10R10	300-223	22K Ohm	10%	1/4 W	Comp	01121	RC07GF223K
A10R11	300-473	47K Ohm	10%	1/4 W	Comp	01121	RC07GF473K
A10R12	300-100	10 Ohm	10%	1/4 W	Comp	01121	RC07GF100K
A10R13	300-103	10K Ohm	10%	1/4 W	Comp	01121	RC07GF103K
A10R14	302-681	680 Ohm	10%	1 W	Comp	01121	RC32GF681K
A10R15	302-681	680 Ohm	10%	1 W	Comp	01121	RC32GF681K
A10R16	300-472	4.7K Ohm	10%	1/4 W	Comp	01121	RC07GF472K
A10R17	315-057	8.06K Ohm	1%	1/8 W	Met Film	91637	RN60C8061F
A10R18	315-092	14K Ohm	1%	1/8 W	Met Film	91637	RN60C1402F
A10R19	300-152	1.5K Ohm	10%	1/4 W	Comp	01121	RC07GF152K
A10R20	300-152	1.5K Ohm	10%	1/4 W	Comp	01121	RC07GF152K
A10R21	302-153	15K Ohm	10%	1 W	Comp	01121	RC32GF153K
A10R22	302-103	10K Ohm	10%	1 W	Comp	01121	RC32GF103K
A10R23	300-101	100 Ohm	10%	1/4 W	Comp	01121	RC07GF101K
A10R24	304-025	20K Ohm	10%	1/2 W	WW Lin Var	91637	2387
A10R25	300-102	1K Ohm	10%	1/4 W	Comp	01121	RC07GF102K
A10R26	300-471	470 Ohm	10%	1/4 W	Comp	01121	RC07GF471K
A10R27	300-332	3.3K Ohm	10%	1/4 W	Comp	01121	RC07GF332K
A10R28	300-103	10K Ohm	10%	1/4 W	Comp	01121	RC07GF103K
A10R29	300-103	10K Ohm	10%	1/4 W	Comp	01121	RC07GF103K
A10R30	300-472	4.7K Ohm	10%	1/4 W	Comp	01121	RC07GF472K
A10R31	300-153	15K Ohm	10%	1/4 W	Comp	01121	RC07GF153K
A10S1	210-006	Switch, Rotary				18786	
A10S2	210-008	Switch, Pushbutton				81073	23-1
A10S3	210-004	Switch, Rotary				18786	
A10S4	210-004	Switch, Rotary				18786	
A10S5	210-014	Switch, Rotary				18786	
A10S6	210-004	Switch, Rotary				18786	
A10S7	210-009	Switch, Toggle				73559	AA252-71
A10S8	210-009	Switch, Toggle				73559	AA252-71
A10TB1	236-001	Terminal Block				75382	41Q-Y-18
A10T1	200-021	Transformer, Power				18786	
A10T2	200-019	Transformer, Power				18786	
A10T3	200-020	Transformer, Power				18786	
A10TB1	236-001	Terminal Block				75382	410-Y-18

CODE LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00213	Sage Electronics Corp.	Rochester, N.Y.
00348	Microtron Co., Inc.	Valley Stream, N.Y.
00373	Garlock, Inc.	Cherry Hill, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp. Inc.	Harrisburg, Pa.
00853	Sangamo Electric Co.,Pickens Div.	Pickens, S.C.
00929	Microlab, Inc.	Livingston, N.J.
01002	General Electric Co., Capacitor Dept.	Hudson Falls, N.Y.
01009	Alden Products Co.	Brockton, Mass.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor & Materials Div.	Somerville, N.J.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03818	Parker Seal Co.	Los Angeles, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Arco Electronic Inc.	Great Neck, N.Y.
04404	Dymec Div. of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Ariz.
04732	Filtron Co., Inc. Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04811	Precision Coil Spring Co.	El Monte, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05397	Union Carbide Corp. Linde Div., Kemet Dept.	Cleveland, Ohio
05574	Viking Ind., Inc.	Canoga Park, Calif.
05624	Barber Colman Co.	Rockford, Ill.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering, Inc.	Wakefield, Mass.
06090	Raychem Corp.	Redwood City, Calif.
06175	Bausch & Lomb Optical Co.	Rochester, N.Y.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06812	Torrington Mfg.Co., West Div.	Van Nuys, Calif.

CODE LIST OF MANUFACTURERS (CONT'D)

Code No.	Manufacturer	Address
06980	Varian Assoc. Eimac Div.	San Carlos, Calif.
07065	Line Electric Co.	Parsippany, N.J.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp., Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07256	Silicon Transistor Corp.	Carle Place, N.Y.
07261	Avnet Corp.	Culver City, Calif.
07263	Fairchild Camera & Inst. Corp., Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Bircher Corp., The	Monterey Park, Calif.
07397	Sylvania Elect. Prod. Inc., Mt.View Operations	Mountain View, Calif.
07700	Technical Wire Products, Inc.	Cranford, N.J.
07829	Bodine Elect Co.	Chicago, Ill.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N.J.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Can.
08524	Deutsch Fastener Corp.	Los Angeles, Calif.
08718	ITT Cannon Electric, Inc., Phoenix Div.	Phoenix, Ariz.
08727	National Radio Lab. Inc.	Paramus, N.J.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Can.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11242	Bay State Electronics Corp.	Waltham, Mass.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N.J.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12574	Gulton Ind. Inc. Data System Div.	Albuquerque, N.M.
12697	Clarostat Mfg. Co.	Dover, N.H.
12881	Metex Electronics Corp.	Clark, N.J.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13103	Thermolloy	Dallas, Texas
13511	Amphenol Corp.	Los Gatos, Calif.
14099	Sem-Tech	Newbury Park, Calif.
14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
14493	Hewlett-Packard Co.	Loveland, Colo.
14655	Cornell Dublier Electric Corp.	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
16179	Omni-Spectra Inc.	Detroit, Ill.
16758	Delco Radio Div. of G.M. Corp.	Kokoma, Ind.
18083	Clevelite Corp., Semiconductor Div.	Palo Alto, Calif.
18324	Signetics Corp.	Sunnyvale, Calif.
18486	TRW Elect.Comp. Div.	Des Plaines, Ill.

CODE LIST OF MANUFACTURERS (CONT'D)

Code No.	Manufacturer	Address
18583	Curtis Instrument, Inc.	Mt.Kisco, N.Y.
18786	Micro-Power Inc.	Long Island City, N.Y.
18911	Durant Mfg. Co.	Milwaukee, Wisc.
24455	G.E. Lamp Div.	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
28520	Heyman Mfg Co.	Kenilworth, N.J.
30817	Instrument Specialties Co., Inc.	Little Falls, N.J.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Can.
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
54294	Shallcross Mfg Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Corp.	Bristol, Conn.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66346	Minnesota Mining & Mfg. Co. Revere Mincom Div.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control	New York, N.Y.
70318	Allmetal Screw Product Co., Inc.	Garden City, New York
70417	Amplex, Div. of Chrysler Corp.	Detroit, Mich.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70674	ADC Products, Inc.	Minneapolis, Minn.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionics Corp.	Cambridge, Mass.
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst, L.I.,N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wisc.
71616	Commercial Plastics Co.	Chicago, Ill.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.

CODE LIST OF MANUFACTURERS (CONT'D)

Code No.	Manufacturer	Address
71984	Dow Corning Corp.	Midland, Mich.
72259	Nytronics Inc.	Berkeley Heights, N.J.
72619	Dialight Corp.	Brooklyn, N.Y.
72765	Drake Mfg. Co.	Harwood Heights, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72962	Elastic Stop Nut Corp.	Union, N.J.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73445	Amperex Elect. Co.	Hicksville, L.I., N.Y.
73506	Bradley Semi-conductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
73957	Groov-Pin Corp.	Ridgefield, N.J.
74276	Signalite Inc.	Neptune, N.J.
74861	Industrial Condenser Corp.	Chicago, Ill.
74970	E.F. Johnson Co.	Waseca, Minn.
75263	Keystone Carbon Co. Inc.	St. Marys, Pa.
75378	CTS Knights Inc.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77221	Phanostran Instrument & Electric Co.	South Pasadena Calif.
77342	American Machine & Foundry Co., Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Div.	Brooklyn, N.Y.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78277	Sigma	So. Braintree, Mass.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Co.	Newburgh, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80813	Dimco Gray Co.	Dayton, Ohio
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Elect. Div. Litton Ind., Inc.	Oakville, Conn.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Div. Barry Wright Corp.	Watertown, Mass.
81862	Electric Components Corp.	Addison, Ill.
82142	Jeffers Electronics Div. of Speer Carbon Co.	Du Bois, Pa.
82219	Sylvania Electric Products, Inc., Electronic Tube Div.	Emporium, Pa.

CODE LIST OF MANUFACTURERS (CONT'D)

Code No.	Manufacturer	Address
82389	Switchcraft, Inc.	Chicago, Ill.
82866	Research Products Corp.	Madison, Wisc.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83315	Hubbell Corp.	Mundelein, Ill.
83324	Rosan Inc.	Newport Beach, Calif.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83594	Burroughs Corp. Electronic Tube Div.	Plainfield, N.J.
83740	Union Carbide Corp. Consumer Prod. Div.	New York, N.Y.
84171	Arco Electronics Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
86684	Radio Corp. of America, Electronic Comp & Devices Div.	Harrison, N.J.
87034	Marco Industries	Anaheim, Calif.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
89231	Graybar Electric Co.	Oakland, Calif.
90030	United Shoe Machinery Corp.	Beverly, Mass.
91146	ITT Cannon Elect.Inc. Salem Div.	Salem, Mass.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91737	Gremar Mfg. Co.,	Wakefield, Mass.
91929	Honeywell Inc., Micro Switch Div.	Freeport, Ill.
92702	IMC Magnetics Corp.	Westbury, L.I.,N.Y.
92966	Hudson Lamp Co.	Kearney, N.J.
93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93929	G.V. Controls	Livingston, N.J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Wagner Elect. Corp. Tung-Sol Div.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	East Paterson, N.J.
94375	Automatic Metal Products Co.	Brooklyn, N.Y.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corporation	Bloomfield, N.J.
95354	Methode Mfg. Co.	Rolling Meadows, Ill.
95566	Arnold Engineering Co.	Marengo, Ill.
95712	Dage Electric Co. Inc.	Franklin, Ind.

APO 290.5

CODE LIST OF MANUFACTURERS (CONT'D)

Code No.	Manufacturer	Address
95984	Siemon Mfg. Co.	Wayne, Ill.
95987	Weckesser Co.	Chicago, Ill.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96341	Microwave Associates, Inc.	Burlington, Mass.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98220	Hewlett-Packard Co., Moseley Div.	Pasadena, Calif.
98278	Microdot, Inc.	So.Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98376	Zero Mfg. Co.	Burbank, Calif.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99313	Varian Associates	Palo Alto, Calif.
99378	Atlee Corp.	Winchester, Mass.
99707	Control Switch Div. Controls Co. of America	El Segundo, Calif.
99942	Hoffman Electronics Corp. Semiconductor Div.	El Monte, Calif.
99957	Technology Instrument Corp.of Calif.	Newbury Park, Calif.

WARRANTY

MODEL 221 BASIC UNIT

All Micro-Power, Inc. products are warranted to the original purchaser against defective material and workmanship for a period of one year after date of initial shipment. Our liability is limited to repairing or replacing any defective part with the exception of vacuum tubes, panel lamps and fuses, provided:

1. Micro-Power, Inc. is notified in writing upon discovery of such defects, noting the model, serial number and a brief statement of the fault, and

2. the defective product is returned to us, transportation charges prepaid by purchaser.

3. The examination of such product by Micro-Power, Inc. shall disclose to its satisfaction that such defects exist and have not been caused by improper installation or application, neglect, repair, alteration, misuse or accident.

Under no circumstances shall Micro-Power, Inc. be liable for collateral or consequential damages of any nature.

This warranty is in lieu of all other warranties, expressed or implied.

MP MASTER
MA31869